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Review of Environmental Issues of the Transportation of Alaskan North Slope Crude Oil

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The onset of Alaskan and offshore West Coast Oil requires west-to-east movement of oil which is in excess of anticipated West Coast demand. Proposals for this movement include Canadian and U.S. pipelines to carry crude to Northern Tier States which face a decline in Canadian exports, pipelines from California to mid-western states, tanker traffic through a canal in Central America or around Cape Horn, and exchanges of oil with foreign countries.

Environmental issues center on impacts affecting air and water quality. Air pollution as a result of offloading, venting, purging, ballasting, and oil storage may require stringent mitigating measures or emissions tradeoffs, especially in non-attainment areas. The degree of water pollution impact is contingent upon the risk of oil spills, probable oil spill trajectories, and the environmental characteristics associated with a particular alternative.

Information is needed in the following areas: the future flexibility in meeting unanticipated supply and demand patterns, how the distribution of natural gas supplies affect the movement of the crude oil and its environmental impacts, accurate air quality models, a West Coast vessel traffic control system, and how present decisions requiring measures to mitigate air impacts may set a precedent for future ventures.

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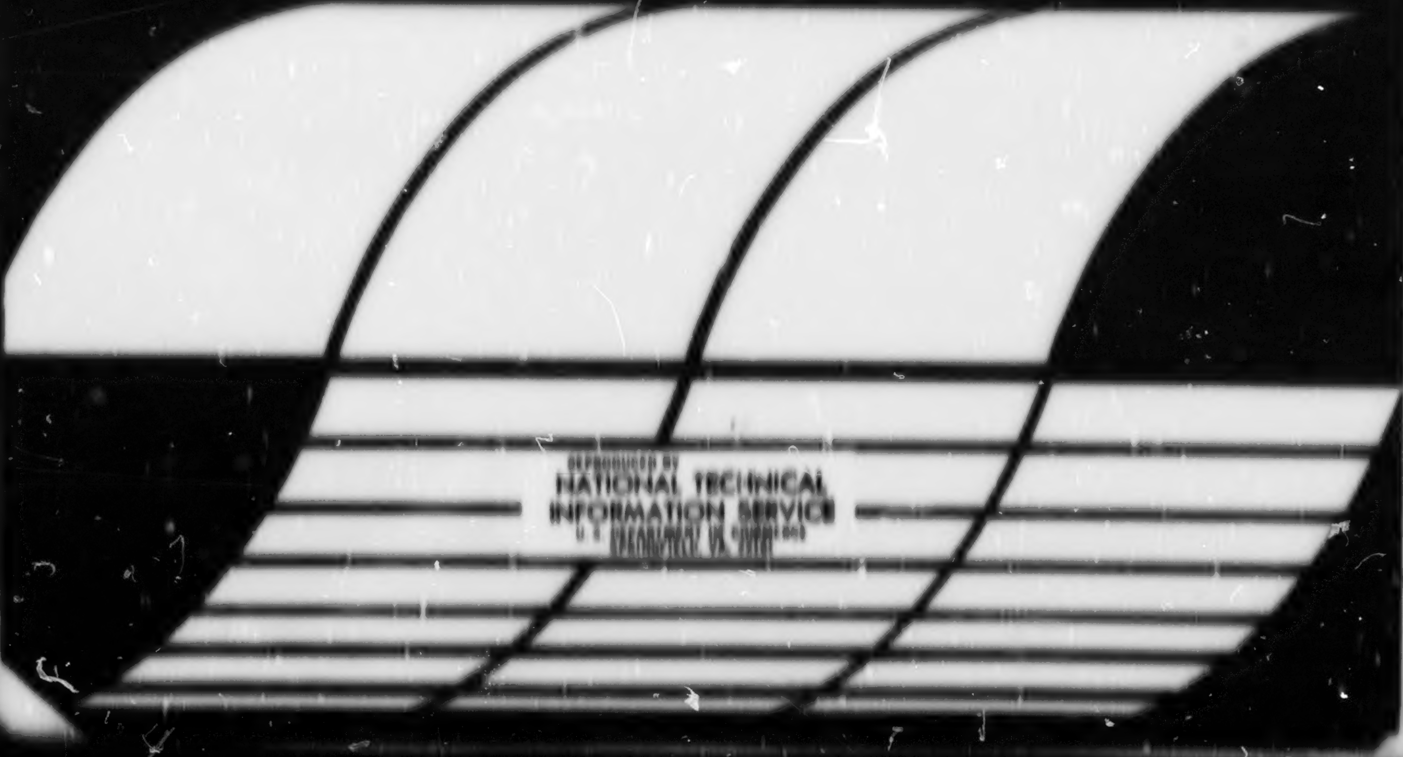

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REVIEW OF ENVIRONMENTAL ISSUES OF THE TRANSPORTATION OF ALASKAN NORTH SLOPE CRUDE OIL

Contract: 68-01-3188

Project Officer: Richard Ball
Office of Energy, Minerals and Industry
Washington, D.C. 20460

Office of Energy, Minerals and Industry
Office of Research and Development
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Washington, D.C. 20460

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FOREWORD

New large scale energy projects pose a challenge to man and his environment. Adverse physical, chemical, or biological conditions could occur as a result of impacts upon the quality of air, land, or water. The Office of Energy, Minerals and Industry conducts a multidisciplinary interagency research program designed to identify health and environmental impacts associated with new energy projects and to develop control equipment and methods to minimize adverse effects.

This report focuses on the environmental issues associated with the transportation of oil from Alaska and is part of our interagency program responsibilities for integrated assessment of the impacts of energy development. The purpose of this study is to identify research and development leads with respect to the movement of North Slope oil. This report also is useful as a summary of 1) the various factors which have contributed to the need for transporting crude oil to areas outside of the West Coast, 2) the various alternatives proposed to distribute the excess oil, 3) the environmental considerations related to such distribution, as well as 4) the research and development needs in areas where data are incomplete with respect to environmental issues. This report also is useful in providing a perspective as to where we have been and where we are in relation to the movement of Alaskan oil, and to how we may prepare for the future to assure environmental compatibility. It is envisioned that this report can be utilized by analysts interested in the problems of Alaskan oil and by administrators, scientists, and concerned citizens who have input to the formulation of policy, decisions, and environmental programs associated with the disposition of Alaskan Oil.

Stephen J. Gage
Deputy Assistant Administrator
for Energy, Minerals, and
Industry

PREFACE

During 1973, when the Trans-Alaskan Pipeline Authorization Act was being debated, the Interior Department estimated that the demand for petroleum over that provided by domestic production would result in the complete consumption of North Slope oil within California and other West Coast states. Present conditions indicate that an excess in available crude oil supply over demand will range from 600 thousand barrels per day in 1978 to as much as 1.3 million by the end of 1985. Various alternatives have been proposed for the distribution of this excess in ways which will allow it to be utilized by other parts of the United States. The establishment of these new distribution systems can pose problems with respect to the environment and human health.

The purpose of this document is to describe the issues related to the movement of North Slope oil to refineries, to review the state of knowledge as it pertains to these issues, and to identify information gaps, inconsistencies, and the need for specific research efforts. The focus of attention is placed upon environmental implications.

It is the intention of this report to serve as a summary of existing information and, except for recommendations for further studies, not produce new information. This report may be utilized by policy and decision makers as a concise summary of the state of knowledge relevant to the movement of Alaskan oil.

ABSTRACT

This document is a summary of existing information related to the transportation of Alaskan North Slope crude oil to U.S. markets. The report focuses upon various factors which have contributed to the need for transporting the crude to areas outside of the West Coast, the various alternatives proposed to distribute the excess oil, the environmental issues related to such distribution, and the research and development needs in areas where data are incomplete with respect to environmental issues.

The onset of Alaskan and offshore West Coast oil requires a new pattern of west-to-east movement of oil which is in excess of anticipated West Coast demand. Proposals for this movement include Canadian and U.S. pipelines to carry crude to Northern Tier States which face a decline in Canadian exports, pipelines from California to midwestern states, tanker traffic through a canal in Central America or around Cape Horn, and exchanges of oil with foreign countries.

Environmental issues center on impacts affecting air and water quality. Air pollution as a result of offloading, venting, purging, ballasting, and oil storage may require stringent mitigating measures or emissions tradeoffs. The degree of water pollution is contingent upon the risk of oil spills and probable oil spill trajectory associated with a particular alternative.

Information is needed in the following areas: 1) how present decisions regarding pipeline routes may preclude future flexibility in meeting unanticipated supply and demand patterns; 2) how decisions related to the distribution of natural gas supplies affect the movement of crude oil; 3) the resolution of localized supply issues; 4) the need for well documented air quality models which describe impacts of marine oil terminals; 5) the development of a regulated West Coast vessel traffic control system; and 6) how present decisions requiring measures to mitigate air impacts may set a precedent for future ventures.

This report was submitted in fulfillment of Contract 68-01-3188 by the METREK Division of the MITRE Corporation under sponsorship of the U.S. Environmental Protection Agency. This report reflects events through January, 1977 and was completed as of March 1, 1977.

CONTENTS

Foreword.. iii
Preface... iv
Abstract.. v
Figures... ix
Tables.. x
Abbreviations and Terms... xii

1. Historical Perspective.. 1
    Evolution of Existing Distribution Systems................................. 1
    Development of Alaskan Reserves.. 5
    Establishment of a West Coast Surplus...................................... 16

2. Alternatives for the Disposition of Alaskan Oil............................. 19
    Focus on the Northern Tier States.. 19
        Canadian Oil Curtailments.. 19
        Trans-Provincial Pipeline.. 19
        Canadian Exchanges... 22
        Trans-Mountain Pipeline.. 24
        Cherry Point Proposal.. 24
        Williams Pipeline.. 24
        Minnesota Pipeline... 25
        Northern Tier Pipeline... 25
        North Slope Crude Oil and the Northern Tier States..................... 26
    International Exchanges.. 27
    Focus on Eastward Movement... 30
        Tankers Through the Panama Canal....................................... 30
        SOHIO Proposal... 31
        Central Alternatives... 33
        An Elk Hills Route... 34
    Other West to East Alternatives.. 35
        Tankers/Tank Car Unit Trains... 35
        Reversal of Four-Corners Pipeline...................................... 36
        Central American Pipeline.. 36
        Around the Horn.. 37
        LOOP-SEADOCK... 37
    Other Solutions.. 38
        Reduced Production of Alaskan Reserves................................. 38
        Strategic Storage.. 39
        Enhancement of West Cost Consumption................................... 39
    Summary Comparison... 40

3. Environmental Issues Related to the Movement of North
    Slope Oil.. 43

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CONTENTS
(Continued)

Quantitative Analysis of Air Quality Issues.............. 43
  Mechanisms for Controlling Air Quality.............. 43
  Existing Air Quality.................................. 49
  Quantitative Measurement of the Issues................ 51
  Project Related Emissions Sources..................... 53
  Emissions Controls/Tanker and Storage Design.......... 53
  Basic Emission Factors................................ 56
  Combustion Pollutants................................. 56
  Hydrocarbon Emissions from Tankers.................... 59
  Hydrocarbon Emissions from Storage Facilities......... 63
  Project Scenarios and Total Emissions................. 63
  Scenario Probabilities................................ 66
  Air Quality Modeling Results.......................... 68
  Summary of Air Quality Analyses....................... 76
Water Quality... 78
  Tanker Status... 79
  Oil Spill Analyses.................................... 79
  Pipeline Spills....................................... 99

4. Pressing Problems....................................103
  National Concern 103
  Future Crude Supplies - New Problems..................105
  Information Needs.....................................108
    Broad Issues..109
    Special Issues......................................110
    Studies Relating to Air Impacts.....................112
    Studies Relating to Water Impacts...................114
    Setting a Precedent.................................114

References..117

FIGURES

Number Page

1 Growth of Crude Oil Pipelines in the United States.......... 3

2 Percentage of Refinery Requirements East of the Mississippi River.. 4

3 Mileage of Petroleum Pipelines in the United States.......... 6

4 Alaskan Production Areas.................................... 7

5 Alaskan Crude Oil Production................................ 8

6 Projected Alaskan Crude Oil Production...................... 13

7 North Alaska Crude Production (BAU) 1975-2000............... 15

8 Canadian Crude Oil Pipelines (1975)......................... 20

9 Actual and Planned Canadian Exports to the United States.... 21

10 Major Alternative Transportation Systems.................... 23

11 Transportation Savings Resulting from Exchanges with Japan.. 29

12 Summary Comparison of Alternatives.......................... 41

13 Air Quality Quantitative Analysis........................... 52

14 Oil Spill Zone -- Kitimat................................... 87

15 Oil Spill Zones -- Northwest................................ 88

16 Oil Spill Zones -- San Francisco............................ 89

17 Oil Spill Zones -- Offshore California and Los Angeles/Long Beach... 90

18 PADD V Supply/Demand Balance Forecast....................... 105

19 Outlooks for North Alaska Crude Production in 1975-2000..... 107

TABLES

Number		Page
1	Referenced Air Quality Related Studies	44
2	Primary Pollutants Emitted by Project	47
3	Ambient Air Quality Standards	48
4	Selected Air Quality Data	50
5	Maximum Hourly SO_x Emissions Rates	58
6	Maximum NO_x Emissions (lbs/hr)	60
7	Maximum HC Emissions (lbs/hr)	62
8	Combustion Pollutants -- Scenarios	64
9	Hydrocarbon Pollutants -- Scenarios	65
10	Annual Probabilities of Occurrence for Air Quality Impacts	67
11	Summary of SO_x Modeling Results -- Port of Long Beach	70
12	Summary of NO_x Modeling Results -- Port of Long Beach	73
13	Summary of Oxidant Modeling Results -- Port of Long Beach	74
14	Relative Spill Risks	82
15	Unweighted Oil Spill Risk Rankings	83
16	Annual Tanker and Terminal Spills by Region and Spill Size	84
17	Unweighted Spill Containment Rankings	85
18	Environmental and Ecological Relative Rankings	91

TABLES
(Continued)

Number		Page
19	Projected SOHIO Tanker Accidents in a 10 Year Period.......	93
20	Projected Tanker Accidents: Valdez to Puget Sound, San Francisco..	94
21	Accident Location and Oil Spillage........................	95
22	Sources of Oil Pollution From Tankers.....................	96
23	Probability Per Year of Spills With Less Than Total Loss...	97
24	Probability Per Year of Spills With a Total Loss...........	98
25	Approximate Predicted Pipeline Statistics..................	100
26	Potential Maximum Oil Spills at Sensitive Locations........	101

LIST OF ABBREVIATIONS AND TERMS

ABBREVIATIONS

API	American Petroleum Institute
AQMA	Air Quality Maintenance Area
ARB	California Air Resources Board
bbl/d	Barrels per day
bpd	Barrels per day
BLM	Bureau of Land Management (U.S. Department of the Interior)
CARB	California Air Resources Board
CBI	Chicago Bridge and Iron Company
CO	Carbon monoxide
CPUC	California Public Utilities Commission
dwt	Deadweight tonnage or the weight in long tons (2,240 pounds) of cargo, fuel, etc. which a vessel is designed to carry safely
EPA	U.S. Environmental Protection Agency
ERT	Environmental Research and Technology, Inc.
FEA	Federal Energy Administration
FOB	Free on board or without charge for delivery to and placing on board a carrier at a specified point
gal	Gallon
HC	Hydrocarbon
lbs	Pounds
LNG	Liquefied natural gas
m	Meter
mb/d	Thousand barrels per day
mmb/d	Million barrels per day
mmcf/d	Million cubic feet per day
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act of 1969
NO_2	Nitrogen dioxide
NO_x	Oxide of nitrogen
NPR1	Naval Petroleum Reserve No. 1 (located in Kern County, California near Bakersfield, commonly known as "Elk Hills")
NPR4	Naval Petroleum Reserve No. 4 (located in northwestern Alaska between the Brooks Mountain Range and the Arctic Ocean and recently, as per PL 94-258, renamed "National Petroleum Reserve in Alaska")

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O_3	Ozone. This molecule is the primary oxidant standard
OCS	Outer Continental Shelf
OPEC	Organization of Petroleum Exporting Countries
Oxidant	A substance used to determine the amount of smog formation
PADD	A Petroleum Administration for Defense District. These areas were established during World War II for the control of petroleum supplies and prices. These areas are still utilized in the reporting of oil production and consumption.
PADD 4	Includes Colorado, Idaho, Montana, Utah, and Wyoming
PADD 5	Includes Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington
PES	Pacific Environmental Services, Inc.
PIRS	Coast Guard Polluting Incident Reporting System
PLB	Port of Long Beach
PPHM	Parts per hundred million
PPM	Parts per million
psia	Pounds per square inch (absolute)
RHC	Reactive Hydrocarbon
S	Sulfur
SCAPCD	Southern California Air Pollution Control District
SCAQMD	South Coastal Air Quality Management District
SES	Socio-Economic Systems, Inc.
SMSA	Standard Metropolitan Statistical Area
SO_2	Sulfur dioxide
SO_x	Oxide of sulfur
SOHIO	Standard Oil Company of Ohio. The SOHIO Valdez, Alaska to Midland, Texas alternative for the movement of North Slope crude is being proposed by a subsidiary: SOHIO Transportation Company of California
TSP	Total suspended particulates
VTS	Vessel Traffic Control System

TERMS

Ambient Air	Air which surrounds a particular point on all sides (generally refers to a non-enclosed environment).
Ballasting	Material, such as water, taken aboard a ship to provide stability, especially when empty.
Freshet	A sudden flood or surge of water in a stream.
Hotelling	The occupancy of a pier overnight by a ship while taking on supplies, fuel, and allowing shore leave for the crew.
Purging	With reference to tankers, it is the act of flushing cargo holds with air or flue gases to remove an explosive atmosphere in the cargo hold or to provide an atmosphere compatible with crew entry (gas freeing)

Segregated ballast	Ballast water that is introduced into a tank which is completely separated from the cargo oil and oil fuel system and which is permanently assigned to the carriage of ballast water.
Seismic	A determination of the consolidation of subsurface rock formations through measurement of the rate of movement of artificially induced shock waves.
Sweet Crude	Crude oil which is low in terms of sulfur content.
Tradeoff	With regard to air quality, it is the substitution of a new, less polluting source of air pollutants for an existing source which is more or equivalent in terms of its contribution to air pollution.
Venting	With respect to tankers, it is the process of allowing gasses from a cargo hold to escape through an opening.

SECTION 1

HISTORICAL PERSPECTIVE

EVOLUTION OF EXISTING DISTRIBUTION SYSTEMS

Within the United States, the first successful exploration and development of crude oil deposits occurred in western Pennsylvania. During 1845 to 1858, oil collected in salt wells near Pittsburgh was bottled and sold as medicine or processed in a five-barrel capacity refinery to produce "carbon oil" for lighting purposes. At this time other petroleum from western Pennsylvania was sold as a lubricant to textile mills. Soon, demand for such products exceeded the supply and the price of oil increased from seventy-five cents to two dollars a gallon (1). The establishment of this market demand provided incentive for increased collection and production of oil for commercial purposes and led to the beginning of the modern oil industry with the successful completion of a drilled oil well in 1859 by "Colonel" Edwin L. Drake. This well, located in north-western Pennsylvania near Titusville produced 20 barrels of crude oil per day and demonstrated that a dependable supply of oil could be obtained by drilling. The success of the well initiated an oil boom in the area including the first flowing well which produced 300 barrels per day in 1861.

Refineries in Oil City near the production field and in Pittsburgh were constructed to process the oil. The crude oil was transported to the refineries in barrels on small boats travelling on freshets released from impoundments in Oil Creek, adjacent to the oil field, and on larger vessels for downstream movement on the Allegheny River to Pittsburgh. As many as 1,000 boats were utilized to carry the oil and as a result of accidents and huge oil losses this method of transporting oil became too expensive and hazardous (2).

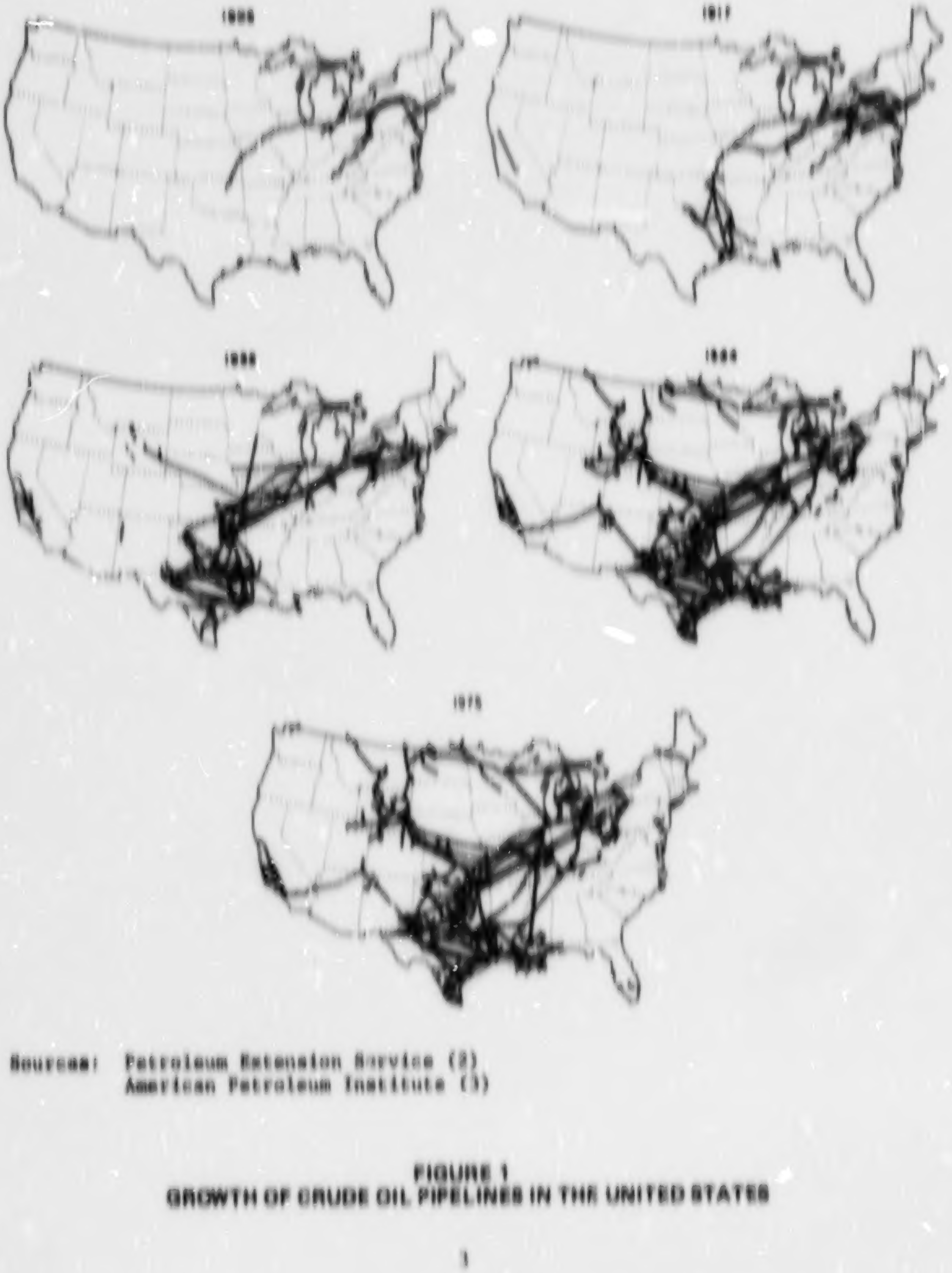
By October, 1861 a rail terminal was constructed at Titusville and by 1864 a rail network provided an outlet for western Pennsylvania crude oil to Cleveland and New York. At first the oil was carried in two wooden tanks of forty barrel capacity mounted on a flat car. These were replaced by iron boiler tank cars by 1869 (2).

During this period the movement of oil from the production site to terminals for water or rail transportation proved difficult. Horsedrawn wagons could carry up to seven 360 pound wooden barrels. On a single day as many as 2,000 of these wagons would transport oil into Titusville. The resultant hazards, congestion, and high cost (as much as $5.00 a barrel) led to the construction of pipeline collector systems. Charging only $0.25 per barrel for the same service; i.e., providing a system for the gathering of oil from field storage tanks, the pipeline as a transportation medium quickly replaced teamsters after 1866.

Initially, railroads bought or constructed pipelines or promoted combines to bring crude oil to rail heads and refused any non-railroad owned pipelines permission to cross the railroad track. Public sentiment against such a monopoly led to the enactment of legislation in Pennsylvania and Ohio in 1872 to grant common carrier pipelines the privilege of eminent domain in their acquisition of rights-of-way (2). This action allowed for the construction of main trunk pipelines and thereby reduced the cost of oil movement. By 1875 the Columbia Conduit System provided a capacity of 12,000 barrels per day to Pittsburgh refineries. The Tidewater Pipe Company constructed a 6 inch pipeline from northwest Pennsylvania to Williamsport, Pennsylvania, adjacent to the Susquehanna River in 1879 and on to Bayonne, New Jersey by the end of 1888. These long distance pipelines resulted in rate reductions by railroads for oil transportation and contributed to the dissolution of the monopolistic transportation of oil by rail combines.

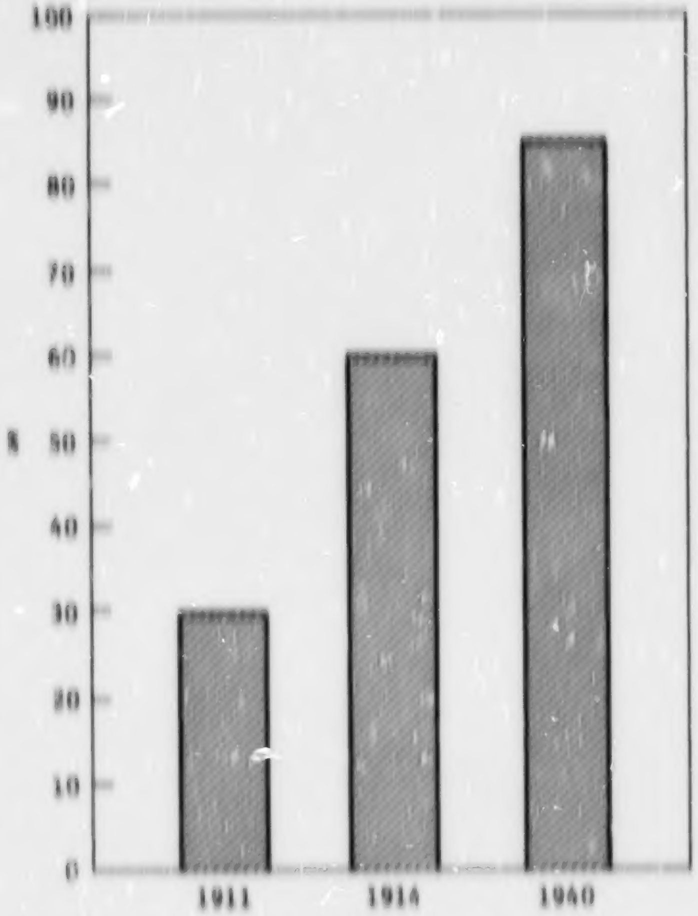
Until 1900 the production of crude oil centered in the east-central states of Pennsylvania, Ohio, Indiana, West Virginia, and Kentucky. The crude oil pipeline distribution system connected production areas to eastern refineries (Figure 1). After 1900, declining production of crude in this area forced the eastern refineries to obtain crude from newly discovered deposits in Texas, Oklahoma, Louisiana, and California. Crude pipelines were constructed to convey the crude from areas of surplus in the mid-continent to meet eastern demand requirements. By 1940 more than 85 percent of crude oil supplies to eastern refineries were derived from production areas located west of the Mississippi River (Figure 2). During this period of pipeline construction, the center of the U.S. population was shifting west creating a demand which was satisfied through the erection of refineries near navigable waters of the Great Lakes, Mississippi River, Texas Gulf, and the coast of California (2). This period of expansion of pipeline systems resulted in the connection of new oil producing areas to new and existing refineries, and to marine terminals (Figure 1).

Prior to World War II large amounts of crude oil and refined products were transported to the east coast by marine tankers and barges. In June 1940 these shipments averaged 1,472,000 barrels per day (2). The war effort required the diversion of tank ships from domestic service and exposed Gulf to East Coast shipping to submarine attack. In 1942, 48 of these remaining tank ships were sunk within four months, resulting in less than one cargo to be delivered daily to the eastern seaboard. As an interim solution to this supply problem, the railroads and the oil industry coordinated the use of 107,000 oil tank cars in fuel trains which would run on a fast schedule. These trains transported more than one million barrels per day of crude oil or its products to the East Coast and about 165,000 barrels daily to California.



Sources: Petroleum Extension Service (2)
American Petroleum Institute (3)

FIGURE 1
GROWTH OF CRUDE OIL PIPELINES IN THE UNITED STATES



Source: Petroleum Extension Service (2)

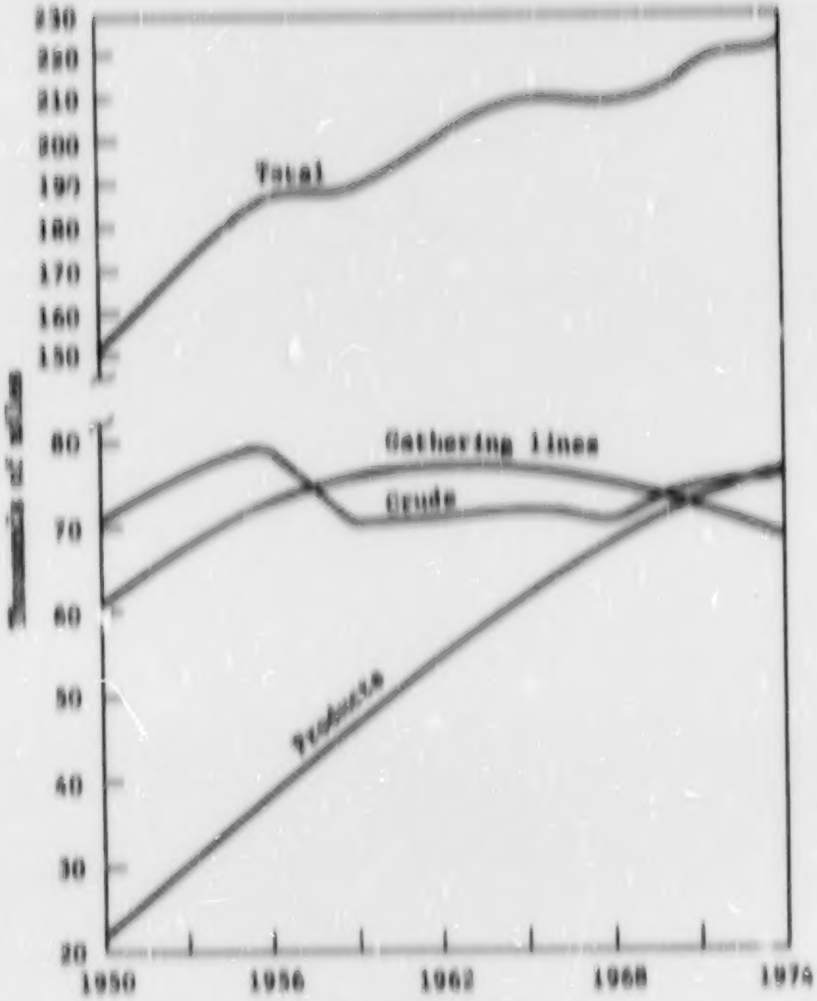
FIGURE 2
PERCENTAGE OF REFINERY REQUIREMENTS EAST OF THE MISSISSIPPI RIVER SUPPLIED BY MID-CONTINENT FIELDS LOCATED WEST OF THE MISSISSIPPI

To aid acceleration of oil pipeline construction during the war, Congress passed the Cole Act of 1942 which allowed the President the right to grant a petroleum pipeline the right of eminent domain when acquiring land and rights-of-way during wartime. Within two years this accelerated construction provided more than 11,000 miles of new pipeline, 3,000 miles of relocation and modernization of older lines, and 3,000 miles of reversed flow in existant lines. Pipeline flow increased from prewar levels of less than 50,000 barrels per day to the east coast to a maximum of 754,000 barrels.

Subsequent to the war many oil pipelines were taken out of service, reversed, or converted to gas pipelines as military demands for petroleum declined. Tankers soon became available for inter-coastal shipments. During the war, large diameter trunk lines proved to be capable of transporting large amounts of oil at a low cost per barrel relative to smaller diameter lines. Such a condition marked the beginning of a new era in U.S. pipeline construction which extended through the 1950's, 1960's, and to the present time. This period of time is characterized by the construction of large diameter trunk lines over long distances (Figure 2) and resulted in greatly increased pipeline capacities. Many of these newly constructed pipelines, especially in the 1950's, replaced older multiple small diameter lines which served the same areas. These older lines were removed or converted to product pipelines (Figure 3).

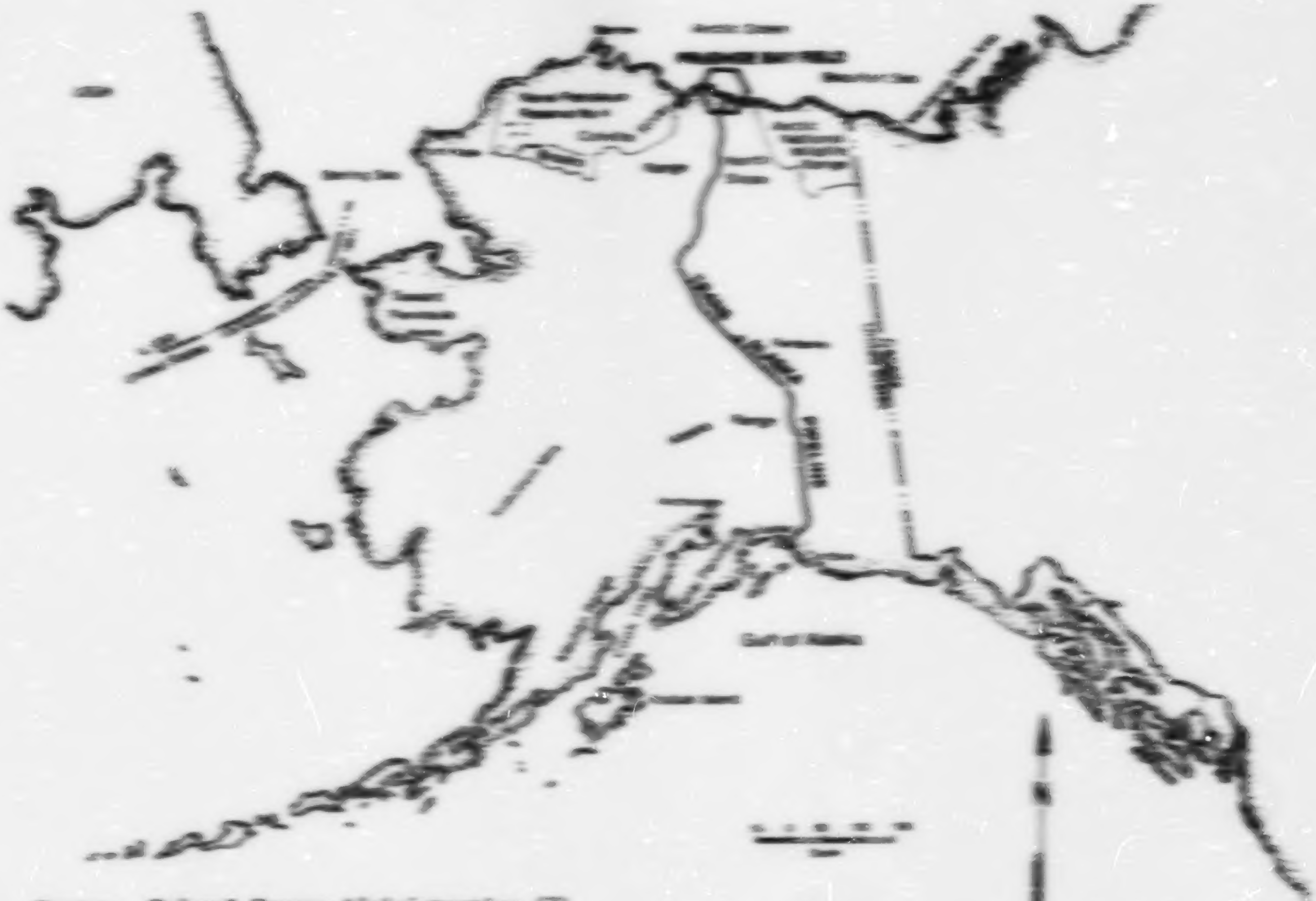
DEVELOPMENT OF ALASKAN RESERVES

In the early 1900's, discoveries of oil seeps were reported by explorers in areas bordering the Gulf of Alaska; in a 190 mile wide area known as Naval Petroleum Reserve No. 4 (NPR4) located in northwestern Alaska between the Brooks mountain range and the Arctic Ocean; and on the North Slope, an area between the Brooks range and the Beaufort Sea and bordered on the west by the Colville River (eastern boundary of NPR4) and on the east by the Arctic National Wildlife Range (Figure 4). During the 1940's the U.S. Navy drilled 37 exploratory wells in NPR4, but the effort was unsuccessful in terms of commercial finds (6). After the Navy's effort, oil companies continued to explore Alaska with seismic analyses and visual observations. These led to the discovery of the Swanson River Field on the Kenai Peninsula in 1957 and in 1963 in the Cook Inlet field. The first refinery opened in 1963 to produce jet fuels and heating oils. By the late 1960's there were seven oil fields in south-central Alaska with production reaching a peak in 1970 of over 80 million barrels (Figure 5). In March 1968 the Atlantic Richfield Company (ARCO) confirmed a flow rate of 1,152 barrels a day from a drill site located near Prudhoe Bay. In June of the same year the company announced the discovery of oil at another site on the North Slope. Within a few months, 14 companies were exploring the North Slope and within a year the number of wells increased from two to thirty (6). As a result, oil consultants estimated the North Slope field to contain 5-20 billion barrels and speculated as high as 50 billion barrels (8). Plans were formulated for the construction of tankers, pipelines, and terminals for the movement of oil from the production sites. Estimates of 1971 or 1972 at the latest were made for the debut of Alaskan oil.



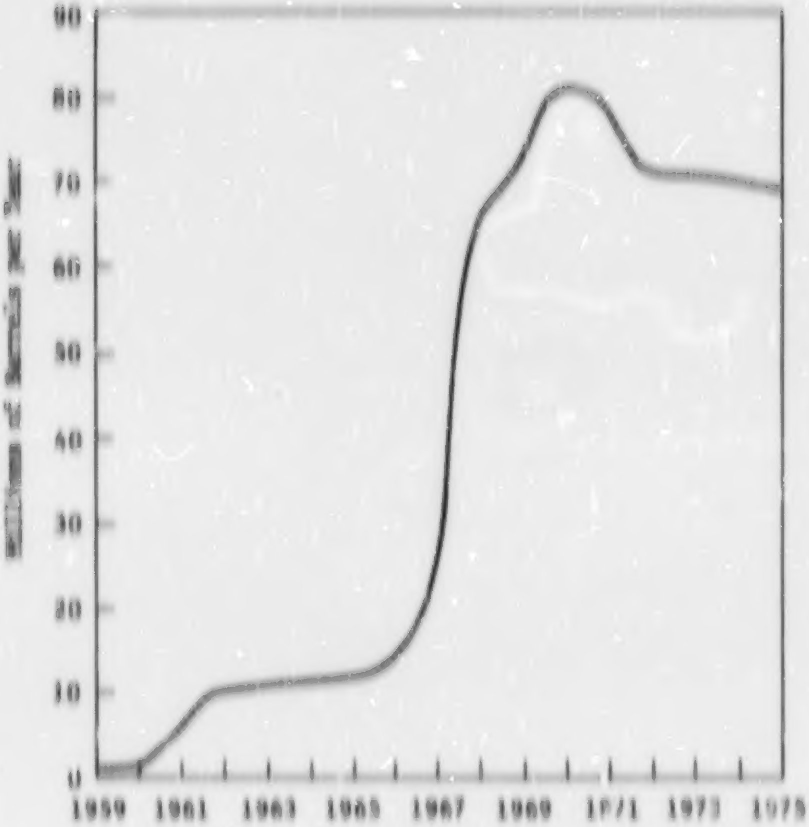
Source: American Petroleum Institute (4)

FIGURE 3
MILEAGE OF PETROLEUM PIPELINES
IN THE UNITED STATES


PIPELINE
Gulf of Alaska

Source: Federal Energy Administration (7)

FIGURE 4
ALASKA PRODUCTION AREAS



Source: American Petroleum Institute (4)

FIGURE 5
ALASKAN CRUDE OIL PRODUCTION

In August 1970 the Alaskan Pipeline Service Company was formed to build and operate a pipeline to transport oil from the North Slope to a warm water port in South Central Alaska. Court injunctions obtained by Alaskan natives and environmental groups forestalled early federal approval of the pipeline. The Native Claims Act was finalized near the end of December 1971 and set aside over five million acres, including the pipeline right-of-way. The final Environmental Impact Statement for the Trans-Alaska Pipeline appeared in March 1972. Opposition to the proposal by leaders of the Canadian government and the U.S. Senate urged that approval be withheld in favor of the construction of a Canadian Line (6). In May, 1972, Secretary of the Interior Rogers Morton announced his decision to grant the right-of-way permit for the trans-Alaska pipeline from the North Slope to Valdez as it would be in the national interest to construct a pipeline "located under the total jurisdiction and for the exclusive use of the United States" (9). In June, 1972 a series of hearings conducted by the Joint Economic Committee reviewed the pros and cons of an Alaskan vs. a Canadian pipeline route. Subsequent to these hearings three environmental groups claimed that the Mineral Leasing Act of 1920 prohibited a right-of-way as wide as that of the proposed pipeline and that the Final Environmental Impact Statement did not adequately consider a specific pipeline corridor through Canada. In early, 1973, the Federal Court of Appeals ruled that the proposed pipeline was in conflict with the Mineral Leasing Act of 1920. The U.S. Supreme Court refused to hear an appeal. In the Spring and Summer of 1973 the Senate considered a bill authorizing the necessary right-of-way through amendment of the Mineral Leasing Act and determining that the 1972 Final Environmental Impact Statement and other Federal actions satisfied the requirements of the National Environmental Policy Act of 1969 (NEPA).

During the debates on the proposed pipeline, advocates included oil companies with reserves in the Prudhoe Bay field, industry and trade associations, and Alaskan administrators. Advocates of a Canadian route included conservation organizations, commercial fishermen, state officials and Members of Congress from the Midwest, and Canadian interests (10). In its report to the Senate concerning the proposed pipeline authorization act, the Committee on Interior and Insular Affairs summarized the controversy over the ability of the West Coast to absorb all of the North Slope oil as follows:

> A surplus of crude oil on the West Coast of the United States would have to be marketed east of the Rockies with considerably greater transportation expense or else exported. Advocates of the Alaska project now acknowledge that the pipeline would have created a crude oil surplus on the West Coast if it had been completed in 1972 or 1973, as originally anticipated.

> The present throughput schedule, however, is not expected to be sufficient to meet all of the District's petroleum demands unless major new reserves are discovered and developed offshore from California or in the Gulf of Alaska. Accordingly, the likelihood of major new oil discoveries in Southern Alaska or off the California coast and the desirability of exporting Alaska oil to other countries during an era of domestic shortages are both among the critical issues of controversy. (11)

At that time the press, the public, and Congress gave little attention to methods of offsetting a potential for a surplus in PADD V (a geographic area for data collection which includes Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington) such as voluntary limitation of production by the oil companies or by the State of Alaska through regulation. It was widely held that the North Slope oil producers favored the Trans-Alaska pipeline-tanker route in part as it provided an opportunity for export of excess supplies to Japan. Spokesmen for these companies and the Department of Interior maintained, however, that the PADD V demand would be more than sufficient to absorb North Slope crude in addition to other PADD V production and that, should an initial surplus develop, U.S. crude oil prices would be high enough relative to other crudes available in the world market to not provide an economic incentive for export (11).

Following the 1973 Arab-Israeli war, the Arab countries imposed an oil embargo as a method of applying pressure on Western backers of Israel. This action led to a substantial rise in oil prices and altered historical supply and demand patterns. In November, 1973 Congress enacted and the President signed the Trans-Alaska Pipeline Act of 1973. The main provisions of the Act (as amended) include the following (12):

1. Amendment of Section 28 of the Mineral Leasing Act of 1920.

    - Limitation of right-of-way width to fifty feet from a pipeline unless a wider right-of-way is approved by the Secretary of the Interior.

    - The Secretary of Interior may require measures to provide for the safety of workers and the public from sudden ruptures and slow degradation of the pipeline.

    - The Secretary also may impose extensive stipulations which protect the quality of the environment from activities associated with proposed or existing rights-of-way.

    - Each right-of-way permit shall permit the Secretary the right to grant additional rights-of-way in the same area in order to minimize environmental impacts and the proliferation of rights-of-way.

- Pipelines and related facilities shall be constructed, operated, and maintained as common carriers.

- A limitation on export wherein the President must find that exports will not diminish the quantity and quality of U.S. petroleum supplies and that the exports are in the national interest. The President must submit his findings to the Congress which has sixty days in which to disapprove such exports. (Presumably, crude oil produced on the outer continental shelf which is not carried by a pipeline across federal lands could be exported) (10).

2. Trans-Alaska Pipeline Authorization

- Authorization for the construction, operation, and maintenance of the trans-Alaska oil pipeline system.

- Rights-of-way shall be subject to Section 28 of the Mineral Leasing Act of 1920 as amended.

- The issuance of Federal rights-of-way, permits, leases, and authorizations for construction and initial operation of full capacity shall not be subject to judicial review under any law (excepting claims against invalidity of this Act).

- The actions relevant to the construction and operation at full capacity of the pipeline, as described in the Final Environmental Impact Statement shall be allowed without further action under NEPA (the Department of Interior draft Environmental Impact Statement on the proposed SOHIO crude oil transportation system from Valdez, Alaska to Midland, Texas examined impacts from tankers on the Valdez air quality, but did not relate to the port operation due to conflict with this section of the Act as impacts of the port were covered under the Trans-Alaska Final Environmental Impact Statement).

- Provisions for liability with respect to pipeline operation and discharges of oil from tankers (12).

Work on the pipeline began in April 1974 under the direction of the Alyeska Pipeline Service Company and involved the construction of almost 800 miles of 48 inch pipeline, twelve pump stations, three crude oil topping plants, an oil storage and shipping complex at Valdez, and various other support facilities. When the first flow of crude oil reaches Valdez in mid-1977, as scheduled, the terminal complex will include 18 storage tanks, three ballast water tanks, a vapor recovery unit and a ballast water treatment plant, and three fixed berths plus one floating berth serve to oil tankers (13). When the pipeline reaches its initial planned flow rate of

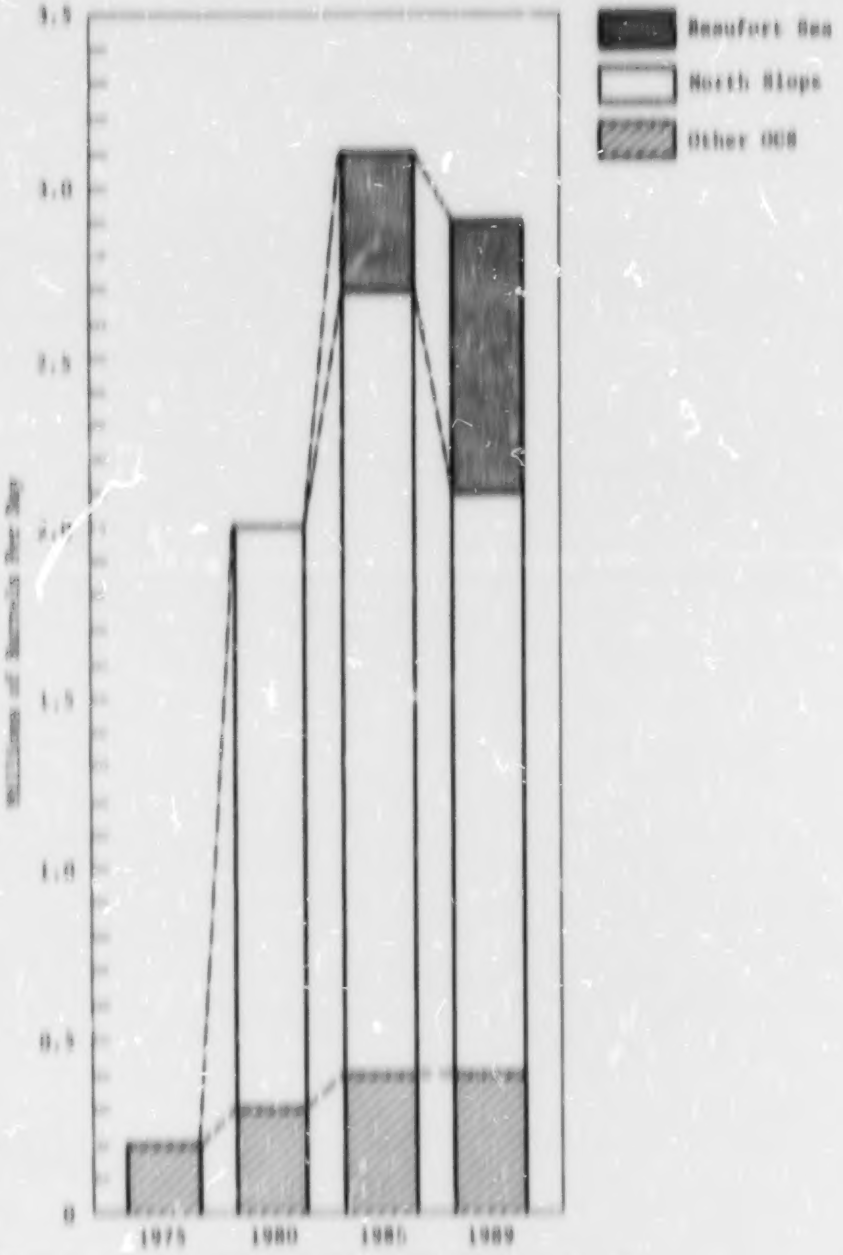
600,000 barrels per day (bbl/d), an average of one tanker per day will load at the port and an average of 1.7 tankers will load each day when the pipeline flow reaches it projected 1.2 million bbl/d rate in 1978 (16).

The mid-1975, Alaskan production of crude oil averaged 191 thousand barrels per day (69,772,000 barrels for the year; Figure 5). Under the Federal Energy Administration's business-as-usual (BAU) projection, Alaskan crude production may reach a peak of 3.1 million barrels per day (mmb/d) during 1985 with most coming from the Prudhoe Bay area of the North Slope (Figure 6). The North Slope oil could account for about 21 percent of the total anticipated domestic BAU crude production in 1985 (7).

The current lessees of interests in the Prudhoe Bay field in order of the percentage of oil in place are: SOHIO (54%), Arco (20%), Exxon (20%), Union (5%), and Phillips, Amerada Hess, and SOCAL (1%). The state of Alaska owns a royalty interest in crude produced from the Prudhoe Bay field and is entitled to 12.5 percent "off the top" of the allocation to each company having production rights in the field. Under the terms of agreement between the companies and the State, Alaska must give 60 days notice as to whether that royalty will be taken in dollars or in oil-in-kind. As of this date, Alaska has elected to take its first royalty in cash, probably because the refineries being built are not ready to receive this oil. However, that can be changed and probably will be changed to a receipt of oil-in-kind as soon as the refineries are completed and provided, of course, the State has exercised its 60 day notice to the companies. In addition to wellhead taxes, the royalty interest provides an incentive for the State of Alaska to encourage a low tariff for the oil passing through the trans-Alaskan pipeline system and high wellhead prices (16, 7).

At present about 9.6 billion barrels in the Prudhoe Bay field are proven in terms of existence and economic viability. The remainder of North Slope oil mostly has been discovered, but its volume and rate of production has not been fully delineated. Based on present information, North Slope reserves other than Prudhoe Bay are expected to be 3.2 billion barrels. Other North Alaska oil deposits lie under the Beaufort Sea and in the Naval Petroleum Reserve No. 4 (NPR 4). The reserves under the Beaufort Sea currently are not proven, but are expected to be 2.3 billion barrels. Thus the total proved reserves in North Alaska are expected under BAU conditions to be about 15.1 billion barrels by 1989 (7). This figure does not include oil fields in NPR 4 since they have not been discovered or delineated. However, the U.S. Navy currently is drilling five wells in the area and predicts a potential of at least five billion barrels of recoverable oil in the area (15).

The current trans-Alaska pipeline capacity to serve the expected production from the North Slope is 2.0 mmb/d. A two stage program to add pipeline capacity in uphill segments (looping) can expand the capacity to 2.6 mmb/d. Additional capacity would require a second pipeline. Typically, dollar outlays for pipeline capacity are planned to be recovered over an operating life of at least ten years. The Beaufort Sea production coming on line after 1980 can barely fill the first stage looping capacity of 2.5 mmb/d for the minimum 10-year economic life when combined with



Source: Federal Energy Administration (7)

*Based on business as usual production possibilities at $13 import oil price.

FIGURE 5
PROJECTED ALASKAN CRUDE OIL PRODUCTION*

the Prudhoe Bay and other North Slope production (Figure 7). Maintaining the flow after 1985 will be dependent upon new findings in existing fields or from potential new sources such as NPR-4.

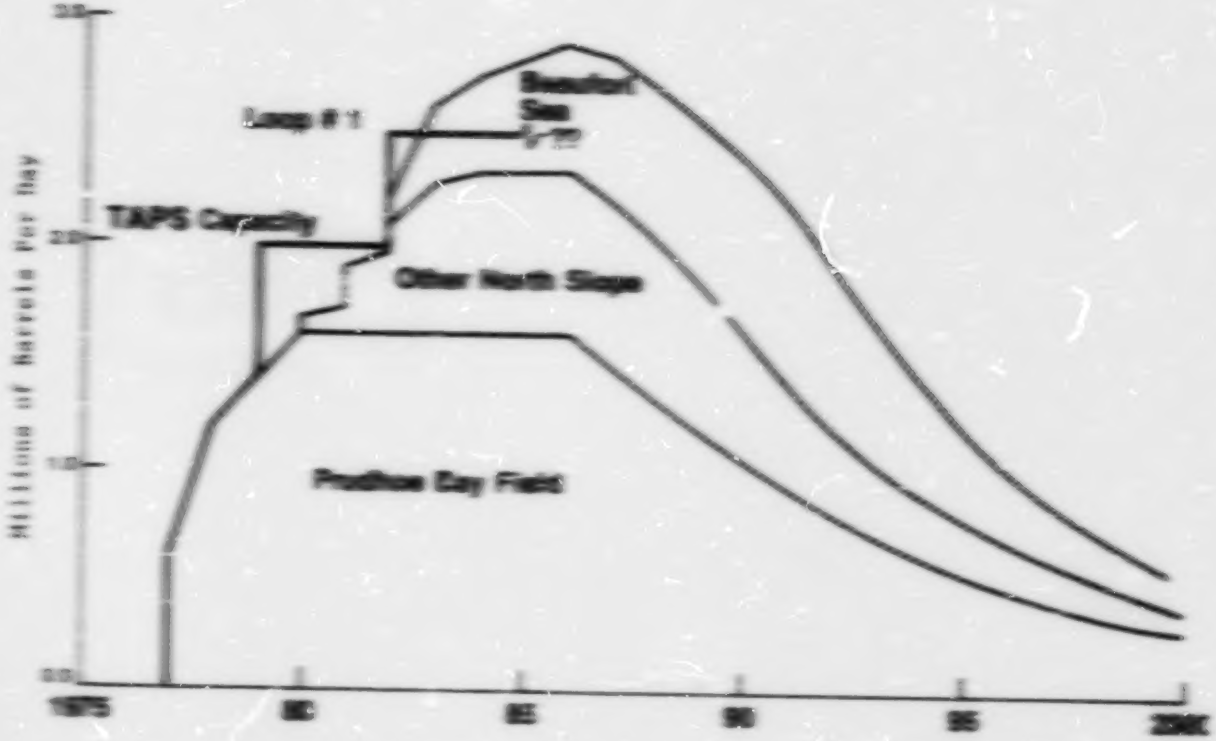
ESTABLISHMENT OF A WEST COAST SURPLUS

Prior to the 1973 oil embargo crude oil prices remained relatively the same from the 1950's to the early 1970's. The major oil producing states held crude production well below full capacity until about 1970. A large amount of relatively low cost foreign crude oil overshadowed the world petroleum market. These factors created a situation marked by a number of important features (7):

- Due to rising costs and low oil prices in the face of cheap foreign oil and the lack of access to unexplored Federal lands (OCS and Alaska), domestic oil drilling declined after 1959.
- As a result, domestic oil reserves (except for the Prudhoe Bay field added in 1970) declined after 1965.
- Domestic production reached a peak in 1970 and subsequently declined steadily.
- Meanwhile, domestic oil consumption increased, reaching a pre-embargo peak in 1973 of over 17 mmb/d.
- The ever widening gap between domestic consumption and domestic production of oil was filled with low cost imports.

After the embargo, the historical trends in the factors which determined petroleum supply and demand changed drastically. A new situation prevailed which was characterized by expensive imports (up to $13 a barrel, excluding import fees) and high domestic crude prices (an increase from $3 to over $8 or to $5 when adjusted for inflation). These factors determined the following conditions in 1974 and 1975 (7):

- Until the enactment of the Energy Policy and Conservation Act in December 1975, price controls continued for "old" oil (on the market before the embargo), but "new" oil brought into production after the embargo sold at the wellhead at a free market price.
- For the first time in recent history, domestic demand declined.
- New drilling sites increased dramatically in 1974 and 1975 to the highest level since 1962.
- An accelerated pace of offshore leasing was undertaken.



Source: Federal Energy Administration (7)

FIGURE 7
NORTH ALASKA CRUDE PRODUCTION (BAU) 1975-2000

- The higher prices stimulated the use of advanced and costly processes to increase oil recovery in existing wells.

- The rate of decline in domestic crude production began to slacken.

- The Congress authorized full production from the Naval Petroleum Reserve No. 1 (Elk Hills, California) which by 1980 will supply oil at a rate of 200 to 350 thousand barrels per day to the West Coast (16).

These factors affected the energy supply and demand patterns for the nation as a whole, but with respect to the potential consumption of North Slope Crude, the situation changed even more significantly after 1973. In April of 1973, the Department of the Interior estimated that the demand for petroleum in PADD V of 2.3 million barrels per day (bbl/d) and its increase to over 4.0 million bbl/d in 1985 would result in full utilization of the North Slope oil as well as the estimated production from declining California fields (17). The combination of events of the oil embargo, subsequent higher petroleum prices, an economic slowdown, and energy conservation measures resulted in a decline in the consumption of oil of over 6 percent in 1974 and 1975. Although domestic consumption is increasing as the economy recovers, current price and conservation measures are expected to result in an estimated growth rate of about 2 percent per year as compared to a 4 percent rate forecasted in 1973 (17).

The production of North Slope crude oil will initially come from the existing field at Prudhoe Bay. Various forecasts by energy companies, research organizations, and Governmental bodies have been made of the amount of North Slope crude oil which will be available to PADD V. These range from 1.5 to 1.7 mmb/d in 1980 to 1.6 to 2.0 mmb/d in 1985 when fields adjacent to Prudhoe Bay could be in production (16).

Another source of oil is from sweet (less than 0.5 percent sulfur) and light (low specific gravity) crude oil imports which will be required by some PADD V refineries (principally in the area of Puget Sound) that can not utilize the relatively heavy North Slope crude containing about one percent sulfur. In Puget Sound, three of the four major refineries utilize the light, low sulfur crude from Canada and Indonesia. In Hawaii, the existing refineries use Indonesian crude (16). The conversion of existing refineries or the construction of new ones which process North Slope crude may take some time owing to down time during modernization in which new process and pollution control equipment are installed, lengthy lead-time for new construction, and uncertainty with respect to the price of North Slope crude. The Federal Energy Administration (16) estimates that 300,000 to 500,000 barrels per day of foreign crude oil could be imported into PADD V through 1980 and from zero to 500,000 barrels per day by 1985 depending upon the price of domestic and imported crude and investment decisions by refiners.

Additional supplies to PADD V will be available as domestic production from offshore drilling and enhanced recovery techniques are applied to existing wells in California. Assuming that domestic crude prices will be decontrolled in 1979 and that a $13 a barrel price (in 1975 dollars) will be in effect in 1980 and 1985, the Federal Energy Administration estimates that the on-shore California production (excluding Elk Hills) is expected to total 1 million barrels per day for 1980 and 1.2 million barrels per day for 1985 (7). Offshore California production is expected to be limited to only 10 and 20 percent of the total production within the State by 1980 and 1985 respectfully. The Elk Hills Naval Reserve production should supply oil at a rate of 200 to 250 thousand barrels per day by 1980 and continue through 1985 should production be allowed to continue past 1982 (current limit as established by legislation).

The total supply to PADD V as estimated by FEA (16) is as follows:

(Million Barrels per Day)

	1978	1980	1985
Alaska	1.3	1.7	1.9-2.3
California	1.1	1.2	1.4
Foreign Imports	.5	.3-.5	.3-.5
	2.9	3.2-3.4	3.6-4.2

Instead of the annual 5 percent growth in the demand for oil in PADD V which was anticipated before the embargo, the demand declined in 1974 and 1975, and slowly increased in 1976. As a result, the current projected rate of growth in demand is 2 percent per year. The actual demand for crude in PADD V is largely due to its demand for products such as gasoline, distillates, residual oil, jet fuels, etc. The product demand varies with geographical regions such as a Northwest need for gasoline and distillates over residual oil (hydro-electric generating capability is presently negating the need to burn residual oil) and a relatively greater need for residual oil in California (which lacks huge amounts of hydroelectric power). Due to its isolation from the rest of the country by the Rocky Mountains, PADD V has tended to be self sufficient with respect to its production of finished petroleum products (16). The Federal Energy Administration (16) has estimated the total product demand in millions of barrels to be 2.3 (1976), 2.6 (1978), 2.3 (1980),* and 2.9 (1985).

Utilizing current information brought to light since the oil embargo, most forecasts of petroleum supply and demand in PADD V predict a crude oil supply surplus when North Slope oil is available. After examining previous forecasts and assuming deregulation of oil and natural gas prices, the Federal Energy Administration utilizes the following reference case for characterizing the surplus (16):

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*Relatively low demand for 1980 reflects FEA forecast of a decline in the use of residual fuel oil in electric plants due to a greater use of nuclear power. 1985 demand may be overestimated.

(Millions of Barrels per Day)

	1978	1980	1985
PADD V Production	2.4	2.9	3.3-3.7
Foreign Imports	.5	.3-.5	.3-.5
Total Supply	2.9	3.2-3.4	3.6-4.2
PADD V Demand	2.4	2.3	2.9
Projected Excess	.5	.9-1.1	.7-1.3

Current information indicates that substantial conversions in the capacity of PADD V refineries designed to run on light, low sulfur crude in order to process North Slope crude will not be made by 1978. Should an economic incentive exist, conversions could be realized by 1985 (17). Thus, it is highly probable that when the Trans-Alaska pipeline attains a flow of 1.2 million barrels per day next year, a 500 thousand barrel per day surplus will be available for movement from PADD V to other areas. Should foreign crude imports not fall below 300 thousand barrels per day and present assumptions concerning supply and demand remain unchanged with time, this surplus could increase substantially by 1980 and by as much as 1.3 million barrels per day in 1985.

A basic assumption of all forecasts has been that production would not be shut-in to maintain an equilibrium between supply and demand in PADD V (16). If this is true, a need exists to develop a transportation method for moving the excess from PADD V to other parts of the U.S. such as the central and eastern areas which are becoming increasingly dependent upon foreign sources of crude oil. Such a west coast to eastward movement would establish a new transportation network and would reflect a change in emphasis from the traditional crude oil sources of the south-central Gulf coast (Figure 1). The network, if established could serve as a distribution system for crudes other than North Slope such as those from NPR-4, Pacific Outer Continental Shelf including Alaska, and heavy oil from on-shore California fields. The availability of nationwide markets for this production at the lowest possible tariffs is an important incentive for development of such a network (17). The following chapters discuss the various transportation alternatives which have been proposed, the major environmental issues and other matters related to these alternatives, and various areas where further information is warranted to prepare for a responsive approach to movement of North Slope crude.

SECTION 2

ALTERNATIVES FOR THE DISPOSITION OF ALASKAN OIL

FOCUS ON THE NORTHERN TIER STATES

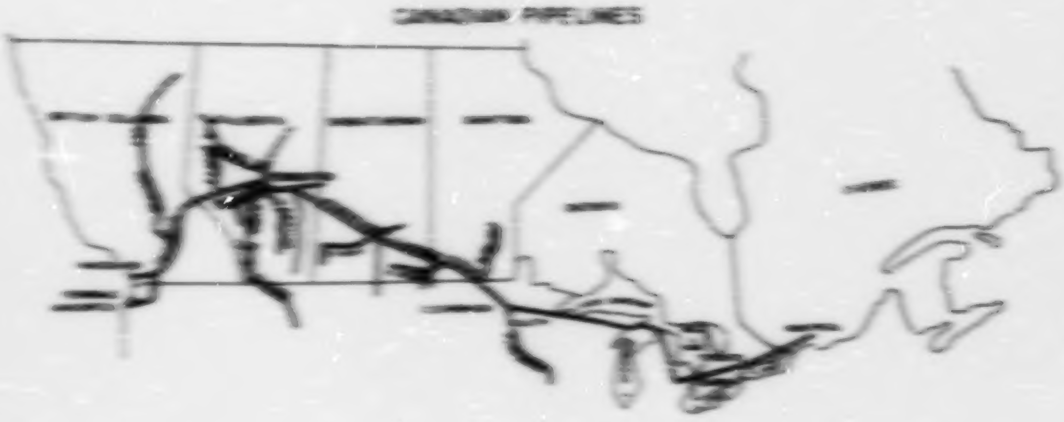
Canadian Oil Curtailments

The discovery of oil in the Canadian Province of Alberta prompted construction of two major crude oil pipeline systems to serve Canadian and U.S. refineries. In 1950 the Interprovincial/Lakehead System was built eastward from Edmonton, Alberta to Superior, Wisconsin. In 1953 the line was extended to Sarnia, Ontario and in 1957 from Sarnia to Toronto. The total length of the Interprovincial/Lakehead network is about 1,969 miles (Figure 8). An 800 mile Trans-Mountain Pipeline System was extended westward from Alberta in 1953. It originated near Edmonton, crossed the Rocky Mountains, and terminated at Vancouver (Figure 8). Short connecting lines have since been added to the Ferndale and Anacortes areas of the northwestern part of the State of Washington (3).

In late 1974, the National Energy Board of Canada announced plans to systematically reduce and eventually terminate Canadian exports to the United States. This decision affected many U.S. refineries which were dependent upon Canadian oil. Some of these refineries located in Ohio, Indiana, and Illinois could utilize alternative supply lines emanating from the Midwest, Southwest, and Gulf Coast. Refineries within the Northern Tier States (Washington, Montana, North Dakota, Minnesota, Michigan, and Wisconsin) rely heavily on the Canadian imports. Only the State of Washington can receive a substantial amount of crude directly from an existing alternate source (imports of crude oil by tanker). The Northern Tier refineries which have no alternative crude source have been given priority status by the Federal Energy Administration to receive available Canadian imports (18). The reductions in Canadian exports to the United States as well as those which are planned are shown in Figure 9. These reductions together with declining local crude production in the face of increased demands pose a significant problem for the Northern Tier States. The following are various alternatives which have been proposed to satisfy, either wholly or in part, the crude oil supply problem.

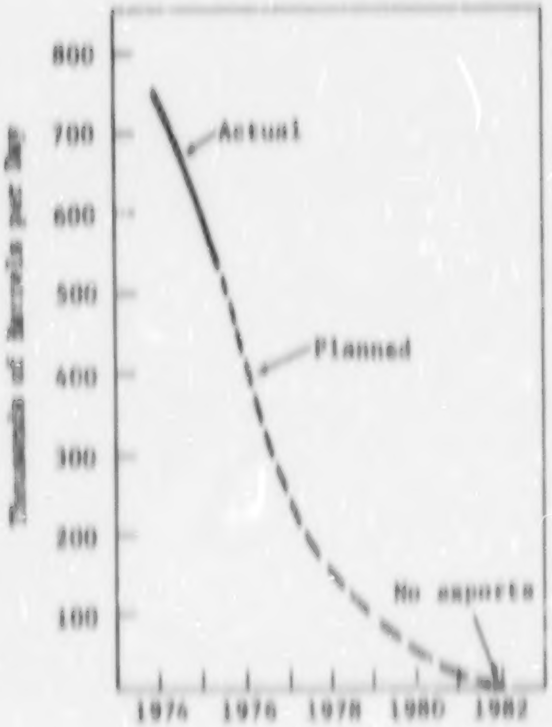
Trans-Provincial Pipeline

This proposal to serve refineries in the Northern Tier States is supported by the firms of Ashland Oil, Canada Ltd., Murphy Oil, Farmers


CANADIAN PIPELINES

Sources: Petroleum Extension Service (2)
American Petroleum Institute (3)

FIGURE 8
CANADIAN CRUDE OIL PIPELINES (1975)



Source: Federal Energy Administration (18)

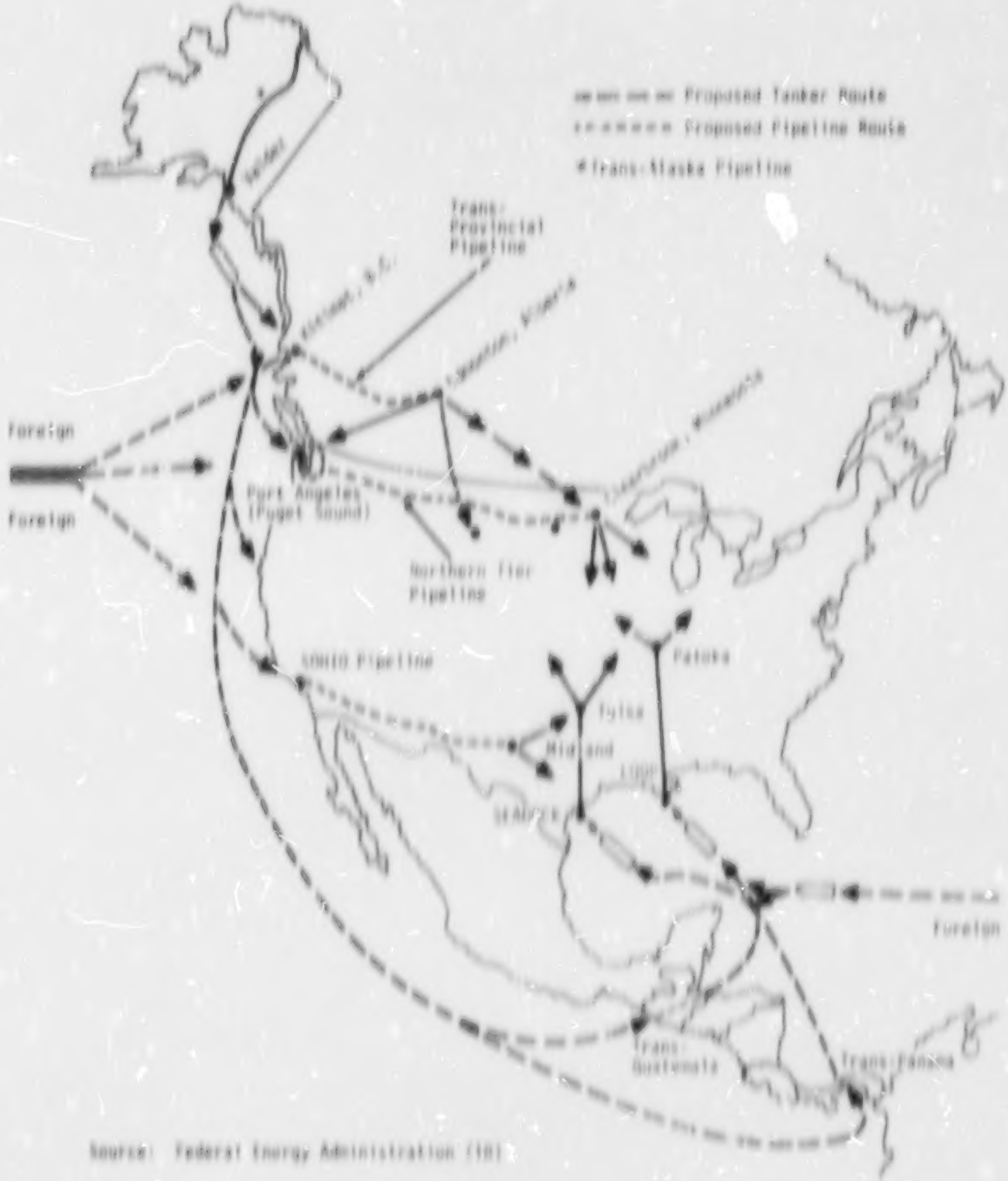
FIGURE 9
ACTUAL AND PLANNED CANADIAN EXPORTS TO THE UNITED STATES

Union Central Exchange, Koch Industries, Hudson's Bay Oil and Gas, and the Interprovincial Pipeline Company. The proposal includes construction of a deepwater port at Kitimat, British Columbia, which would serve a 750 mile, 30 inch pipeline to Edmonton, Alberta where distribution can take place via the Interprovincial-Lakehead Pipeline System (Figure 10). The proposed pipeline is designed to carry 300 thousand barrels per day (to be expanded to 500,000 by 1985) of Alaskan, domestic offshore, Indonesian, and Persian Gulf crudes, and could be operational within 16 to 22 months after permits are finalized (18). The terminal would include two floating docks capable of handling 16,000 - 320,000 dwt oil tankers. The Kitimat port would require minimal dredging to accomodate larger oil tankers as its sheltered Douglas Channel provides 450 ft. of water depth at low tide (19). However, the narrow port entrance channel presents significant navigational problems and allows for the chance of accidents and associated oil spills greater than in most other West Coast ports (20). The Kitimat port does provide an alternative to the tanker transport of Alaskan crude further down the coast to Puget Sound which has met considerable environmental opposition. Recent discussions with tanker captains have indicated that the channel presents no serious navigation problems for the 10,000 to 100,000 dwt class of tankers (21). To date the British Columbia government is critical of the proposal as it would provide few benefits to Canadians, the time schedule is too tight for necessary environmental studies to be undertaken, and there is a potential for tankers as large as 350,000 dwt to visit the port. These likely would be flag-of-convenience ships possessing a minimum of navigation standards and equipment. Such factors as conditions within the Channel entrance and the status of tanker modernization, could contribute to the likelihood of oil spills. Backers of the project hope to begin construction this year with a completion date in early 1979.

Canadian Exchanges

One solution to the Northern Tier supply problem is to initiate exchanges of crude oil between the Northern Tier area and refineries located in the eastern provinces of Canada. Such exchange agreements would preclude Northern Tier refineries from paying the additional cost for the acquisition and transportation of acceptable crude from areas far removed from the Northern Tier. Generally, Canada is willing to consider exchanges as an interim solution to the Northern Tier supply problem until long-term arrangements are established (16).

Since the heavy North Slope crude would only be acceptable to refiners in eastern Canada (refiners in western Canada utilize light, low sulfur crude), it is doubtful that the economic incentive for such a venture would merit such a long distance movement of the North Slope crude. Other more indirect and consequently complex exchanges can be arranged wherein the North Slope crude displaces domestic crude which may be traded with Canadian refiners for release of light, low sulfur Canadian crude to Northern Tier refiners. This alternative would require international negotiation.


Proposed Tanker Route
Proposed Pipeline Route
Trans-Alaska Pipeline
Valdez
Trans-Provincial Pipeline
Kitimat, B.C.
Edmonton, Alberta
Clearbrook, Minnesota
Foreign
Foreign
Port Angeles (Puget Sound)
Northern Tier Pipeline
SOHIO Pipeline
Patoka
Tulsa
Midland
LOOP
SEADOCK
Foreign
Trans-Guatemala
Trans-Panama

Source: Federal Energy Administration (10)

FIGURE 10
MAJOR ALTERNATIVE TRANSPORTATION SYSTEMS FOR THE EASTWARD MOVEMENT OF NORTH SLOPE CRUDE

Trans-Mountain Pipeline

This proposal involves the construction of a tanker terminal in Puget Sound or the use of an existing deepwater terminal such as ARCO's Cherry Point refinery terminal (22). Trans Mountain Pipe Line Company, Ltd., plans to alternate eastward and westward shipments via its pipeline in western Canada (Figure 8). This "yo-yo" proposal can utilize Trans Mountain's current pipeline capacity of 420 thousand barrels a day. Recently, the pipeline has been used for the importation of only 60 thousand barrels a day to four refineries in Washington (to be cut back under Canada's oil curtailment plans) and 120 thousand barrels a day to four refineries in the Vancouver area (22).

Under the proposal, Vancouver can be served by the westward flow of Canadian (or U.S. imported) oil and northern tier refineries can be served by an eastward flow to Edmonton where it could enter the Interprovincial Pipeline System for transport to Minnesota and Illinois. The projected initial eastward flow is 165 thousand barrels a day. Each reversal of flow would take the pipeline out of service for two days (22).

Cherry Point Proposal

This proposal involves the construction of a 1,700 mile pipeline from a terminal in Puget Sound near Cherry Point, Washington to Clearbrook, Minnesota or to Sidney, Nebraska by the construction of a 1,400 mile pipeline. With little construction, the port could accommodate large Alaskan tankers. Charges that the approaches to the site are too hazardous for large tankers initiated the enactment of a 1976 Washington state law which prohibited tankers of more than 125,000 dwt and required tugboat escort of most smaller tankers (23). In September, a Federal three judge panel ruled that the tanker law was pre-empted by Federal jurisdiction. The matter is still in litigation. Owing to navigational problems, the oil spill risk is high and such a spill could affect a rich biotic environment (20).

Williams Pipeline

This proposal is a phased expansion program of an existing products pipeline system in the upper Midwest. The expansion would include 500 miles of 24-inch pipeline from Oklahoma to Iowa and could carry 330 thousand barrels per day of Oklahoma crude oil to Minneapolis, Minnesota. The expansion could be completed within 12 months. This pipeline, proposed by Williams Pipeline Company also could carry oil from existing Gulf Coast pipelines which would connect to the proposed SEADOCK deepwater terminal near Freeport, Texas (18). It also could receive oil from pipelines which would connect to the proposed SOHIO Long Beach - Midland pipeline. Should this project be implemented, it would serve as a partial solution for the crude oil requirements of refiners in Minnesota. It also could serve in the distribution of Alaskan crude in the short term by carrying oil transshipped through the Panama Canal to Gulf Coast ports and in the long-term by serving the SOHIO pipeline.

Minnesota Pipeline

The Minnesota Pipeline Company recently has announced plans to construct a 490 mile, 24 inch crude oil pipeline from Patoka, Illinois to St. Paul, Minnesota. This line also would connect with several major crude trunk lines from the Gulf and West Texas coasts. The proposed line would initially carry up to 250 thousand barrels per day. The pipeline backers are the Ashland Oil Company and Koch Industries. Current plans are to begin construction by early 1977 for an Autumn of 1978 completion date.

Northern Tier Pipeline

The Northern Tier Pipeline Company proposes to construct a 1,550 mile, 42" and 40" diameter pipeline for receiving Alaskan and foreign crude at Port Angeles, Washington and transporting it to Clearbrook, Minnesota where connections would be made with the existing Minnesota Pipeline and Lakehead Pipeline. In addition, the system also would be capable of deliveries to existing pipelines in Montana and North Dakota. Through existing pipeline systems which have surplus capacity available, the Northern Tier Pipeline would be capable of supplying refineries in the Rocky Mountain, North Central, Midwestern and Eastern U.S. (24,25).

The design capacity of the system is approximately 740 thousand barrels a day to Clearbrook with capability of delivering approximately 200 thousand barrels a day to intermediate points in Montana and North Dakota. Provision can be made in the pipeline design to accommodate an additional 350 thousand barrels a day through the initial segment of the pipeline from Port Angeles to Selleck, Washington to supply refineries in the Puget Sound area. To supply these refineries, a connecting spur line 83 miles in length would be constructed to tie in with the existing Trans Mountain Pipeline now serving the four refineries in the Anacortes-Ferndale area.

The Northern Tier Pipeline Company is a Montana corporation formed by six organizations and one individual experienced in the oil and transportation industries (26). The Company is presently negotiating with potential shippers to obtain the throughput commitments necessary for project financing and is proceeding to obtain state and federal permits. The Company applied for Site Certification on July 6, 1976 in the state of Washington with the Energy Facility Site Evaluation Council which administers the state's recently enacted Energy Siting Act. Pending permit approvals, current plans are to start construction in mid 1978 with completion of construction scheduled for year end 1979 (26,27).

The Northern Tier pipeline proposal contains several important features. The pipeline would supply the Northern Tier refineries and would not be subject to future Canadian tariffs or regulations. The larger (42 inch) pipeline laid around Puget Sound could reduce the need for oil to be brought by tankers into the main body of the Sound and thereby decrease the likelihood of oil spills in that area. The route crosses the Williston Basin, an area with deep lying salt deposits along the Montana-North Dakota border. The Northern Tier Pipeline Company indicates that these deposits could be utilized for an inland strategic oil storage area served by the pipeline (25).

A local environmental group, the Coalition Against Oil Pollution, favors the Port Angeles site for the marine terminal over one located in Puget Sound (28), and the State of Washington's coastal zone management program also is favorable to the project. As envisioned last year under Governor Dan Evans, the State's coastal zone management policy "...positively supports the concept of a single, major crude petroleum receiving and transfer facility at or west of Port Angeles" (75). The present Governor (Dixy Lee Ray) views the facilities to be acceptable only if strong controls exist over their development (29). Recent interactions of the Bureau of Land Management with environmental groups in and around the state of Washington indicated little public support for a large marine terminal at Port Angeles (73).

North Slope Crude Oil and the Northern Tier States

Most of the Northern Tier refineries are designed to utilize low-sulfur Canadian oil and are not readily adaptable to operate with the Alaskan Crude. If obtainable, Indonesia light crude with its relatively low sulfur content may become the primary replacement for Canadian oil (30). The influx of Alaskan oil into the West Coast together with its concomitant surplus and its occurrence at a time when the Northern Tier states are experiencing a supply shortage has caused national concern for the need to quickly identify a reasonable solution to the problem. Such concern led the following legislative requirement to be adopted by Congress and approved by the President on October 22, 1976 as part of the Alaska Natural Gas Transportation Act of 1976 (31):

> Sec. 18. Within 6 months of the date of enactment of this Act, the President shall determine what special expediting procedures are necessary to insure the equitable allocation of north slope crude oil to the Northern Tier States of Washington, Oregon, Idaho, Montana, North Dakota, Indiana, and Ohio (hereinafter referred to as the "Northern Tier States") to carry out the provisions of section 410 of Public Law 93-153 and shall report his findings to the Congress. In his report, the President shall identify the specific provisions of law, which relate to any determination of a Federal officer or agency as to whether to issue or grant a certificate, permit, right-of-way, lease, or other authorization in connection with the construction of an oil delivery system serving the Northern Tier States and which the President finds would inhibit the expeditious construction of such a system in the contiguous States of the United States. In addition the President will include in his report a statement which demonstrates the impact that the delivery system will have on

> reducing the dependency of New England and the Middle Atlantic States on foreign oil imports. Furthermore, all Federal officers and agencies shall, prior to the submission of such report and further congressional action relating thereto, expedite to the fullest practicable extent all applications and requests for action made with respect to such an oil delivery system.

Currently this report is in preparation and is to be completed by the end of April this year.

INTERNATIONAL EXCHANGES

It is commonly assumed that all North Slope oil will be transported into the contiguous States and thereby lessen dependence upon imports of foreign oil. It is also commonly believed that the excess of such oil, should it materialize on the West Coast, would be directed to states east of the Rocky mountains. In the short term, however, it is unlikely that an east-west pipeline transportation system will be in place by 1978 when the initial surplus is expected to occur. Consequently, the excess oil will probably be transported by tankers to domestic markets other than the West Coast or may be exchanged with foreign refiners - possibly with the effect of releasing foreign oil for import into the Gulf or East Coast. Such exchanges were addressed specifically in the Trans-Alaska Pipeline Act's amendment of the Mineral Lands Leasing Act of 1920 (12):

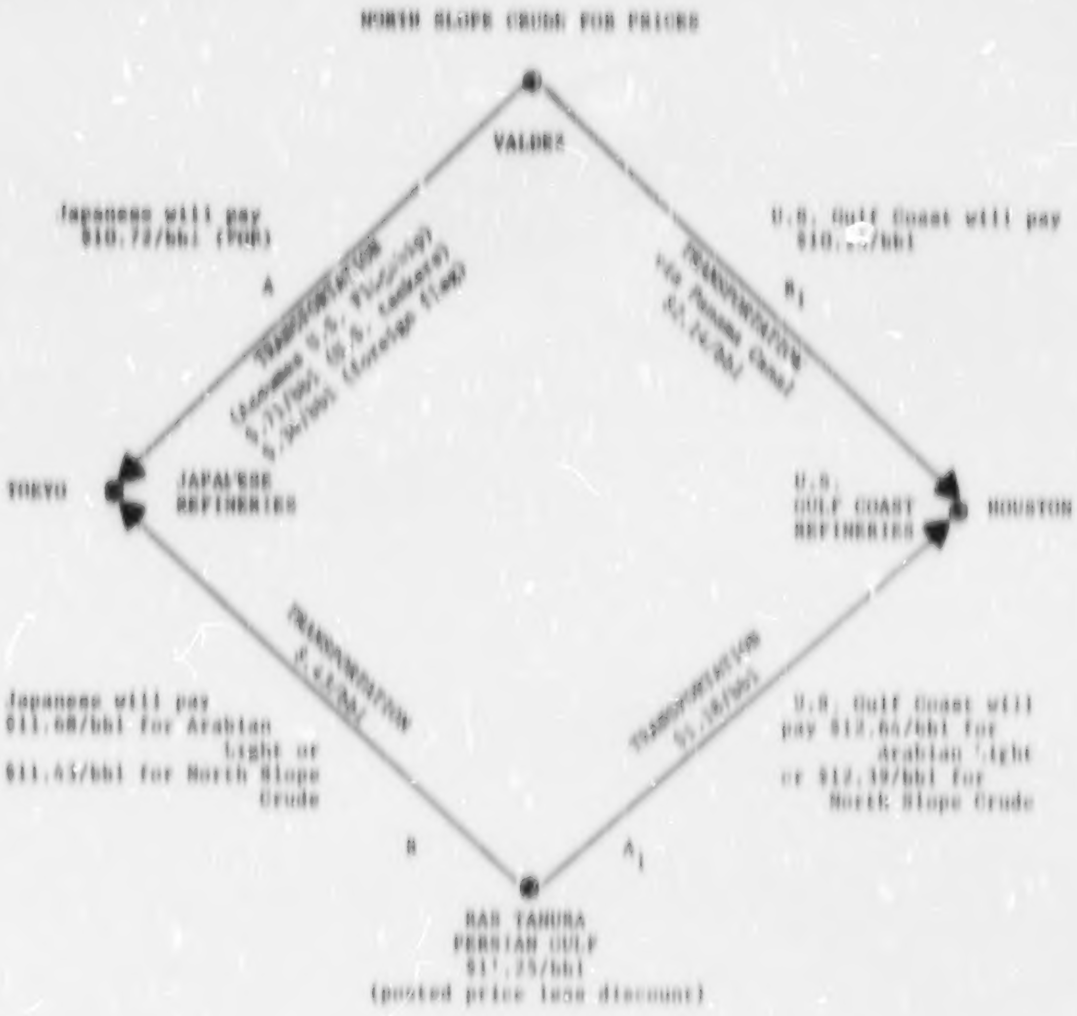
> LIMITATIONS ON EXPORT
>
> (u) Any domestically produced crude oil transported by pipeline over a right-of-way granted pursuant to section 28 of the Mineral Leasing Act of 1920, except such crude oil which is either exchanged in similar quantity for convenience or increased efficiency of transportation with persons or the government of an adjacent foreign state, or which is temporarily exported for convenience or increased efficiency of transportation across part of an adjacent foreign state and re-enters the United States, shall be subject to all the limitations and licensing requirements of the Export Administration Act of 1969 (Act of December 30, 1969; 83 stat. 841) and in addition, before any crude oil subject to this section may be exported under the limitations and licensing requirements and penalty and enforcement provisions of the Export Administration Act of 1969 the President must make and publish and express finding that such exports will not diminish the total quantity or quality of petroleum available to the United States, and are in the national interest and are

> in accord with the provisions of the Export Administration Act of 1969: Provided, that the President shall submit reports to the Congress containing findings made under this secton, and after the date shall have a period of sixty calendar days, thirty days of which Congress must have been in session, to consider whether exports under the terms of this section are in the national interest. If the Congress within this time period passes a concurrent resolution of disapproval stating disagreement with the President's finding concerning the national interest, further exports made pursuant to the aforementioned Presidental findings shall cease.

The language of the Act does not prohibit crude exports absolutely. It was recognized that under some circumstances "import-for-export" arrangements might be desirable. It was also felt that a total ban might prevent or handicap arrangements among oil importing countries to share their domestic or secured foreign supplies in the event of an economically or politically inspired embargo by exporting countries. A categorical prohibition against exporting also could set a precedent and possibly set in motion a retaliation by countries now exporting to the U.S. Finally, it was recognized that the U.S. might, at some time, become not only self sufficient again but actually be in a position to export crude oil, thereby benefiting balance of payments and the national economy (10). The thrust of the above section was to assure that any such exports would be in the national interest by prohibiting exports that would reduce net U.S. supplies, by requiring accord with the licensing requirements of the Export Administration Act which allows the President to set stringent export controls, and by assuring Congressional and Presidential review.

As mentioned, Canadian exchanges are most likely not to involve North Slope crude directly, owing to its relatively higher sulfur content as compared to Canadian crude. However, a projected growth in demand for foreign crude in Japan (totally dependent on foreign sources such as the Middle East, Southeast Asia, Africa, and the Communist bloc nations) where U.S. oil companies are heavily involved in the refining industry make the country a prime candidate for such exchanges (16). Japan has the capability to refine high sulfur crudes and can absorb any likely surplus of North Slope crude. Japanese officials have openly asked U.S. officials to allow export of North Slope crude to Japan (16).

For the short-term crude oil exchanges with Japan appear to provide an economic incentive owing to reduced transportation costs over those associated with the movement of North Slope oil to the Gulf Coast through the Panama Canal (Figure 11). Such "swapping" agreements involve complex negotiations and may take some time to finalize. Once established, however, they may remove the economic incentive for the rapid development of east-west pipeline systems. This could lock out future oil supply sources such as onshore Alaskan, Pacific OCS areas, and enhanced recovery from


NORTH SLOPE CRUDE FOB PRICES
VALDEZ
Japanese will pay $10.72/bbl (FOB)
A
TRANSPORTATION (Assumes U.S. Flagship) $.71/bbl (U.S. tankers) $.34/bbl (foreign flag)
U.S. Gulf Coast will pay $10.[illegible]/bbl
B_1
TRANSPORTATION via Panama Canal $2.14/bbl
TOKYO
JAPANESE REFINERIES
U.S. GULF COAST REFINERIES
HOUSTON
TRANSPORTATION $.43/bbl
TRANSPORTATION $1.18/bbl
Japanese will pay $11.68/bbl for Arabian Light or $11.43/bbl for North Slope Crude
U.S. Gulf Coast will pay $12.64/bbl for Arabian Light or $12.39/bbl for North Slope Crude
B
A_1
RAS TANURA
PERSIAN GULF
$11.25/bbl
(posted price less discount)

ARABIAN LIGHT

No-swap = B($.43/bbl) + B_1 ($2.14/bbl) = $2.57/bbl
swap = A($.71/bbl) + A_1 ($1.18/bbl) = $1.89/bbl

Swap Savings = $.68/bbl (U.S. tankers-Valdez-Japan)
or = $1.05/bbl (foreign flag-Valdez to Japan)

FIGURE 11

TRANSPORTATION SAVINGS RESULTING FROM CRUDE EXCHANGE WITH JAPAN

Source: Federal Energy Administration (16)

California fields from being readily available to midwest and eastern refineries (16).

The main issues frequently raised relevant to foreign exchanges are the following:

1. The U.S. participates in the Emergency Sharing Program of the International Energy Agency wherein participating countries agree to pool secured exports for a coordinated response in the event of an oil embargo. Although U.S. exchange agreements would not affect its entitlement under the Program, a certain amount of North Slope oil would be required to continue to be exported during an embargo. However, the U.S. would be receiving compensating volumes of foreign oil (16). Public officials are concerned that, in the face of public opinion, it may be difficult to justify such exports of domestic oil during an embargo (31).

2. At a time when the nation is striving for self-sufficiency and a reduced dependency on foreign energy sources (32) it is an apparent conflict to export domestic oil.

3. The exchange option is not necessarily in the National Interest since sufficient U.S. tankers exist which are capable of transporting North Slope crude through the Panama Canal.

Recently the Federal Energy Administration Administrator has voiced opposition to such exchanges as it would be nearly impossible, logistically and diplomatically, to suddenly switch from exporting oil to consuming it domestically during another oil embargo (33). About the same time, Senator Stevenson who chaired hearings on the subject favorably indicated that such exchange agreements could produce higher profits for the oil companies, lower costs for consumers, lessen environmental damage (do not require the building of pipelines) and still permit use of all North Slope oil production within the U.S. in the event of an embargo directed at this country (34).

FOCUS ON EASTWARD MOVEMENT

Tankers Through the Panama Canal

The shipment of North Slope oil through the Panama Canal to the Gulf Coast has received a national focus of attention recently since this form of transportation may prove to be viable as a short term solution for the eastward movement of excess crude. Two methods have been proposed to tranship oil through the Canal to the Gulf terminals. One method involves large tankers (120,000 - 250,000 dwt) which would carry the oil from Valdez to the Pacific approaches to the Canal where it would be transhipped in smaller tankers capable of transiting the Canal. The other method involves the use of small tankers (less than 68,500 dwt) to transport North Slope oil over the entire distance. The Federal Energy Administration has determined that the U.S. domestic fleet, augmented by U.S. flag tankers currently in foreign trade service, would be adequate to carry the anticipated 500 thousand barrels of crude per day to the Gulf Coast ports in 1978 (16, 35). The use of small vessels over the entire route would eliminate the need for off-loading at the Pacific entrance to the Canal, but would increase the total number of loading and unloading operations as well as increase the total number of ships travelling along the West Coast and transiting the Canal. As a result the risks for the occurrence of oil spills and ship collisions would increase (20).

An issue of concern is the status of treaty negotiations now underway between the United States and the Republic of Panama. The outcome of these talks may affect the security of the Canal as a passageway for future domestic crude supplies (20).

SOHIO Proposal

The SOHIO Transportation Company of California, a wholly-owned subsidiary of the Standard Oil Company of Ohio, has proposed a 3,500 mile sea/land transportation system to move North Slope crude from the Trans-Alaska Pipeline marine terminal at Valdez, Alaska, to Midland, Texas. From Midland the crude could be distributed eastward through existing pipeline networks. A tanker fleet would carry the crude 2,200 miles to the Port of Long Beach, California where it would be delivered to a storage terminal and then to Texas through a 1,026 mile pipeline system composed of 236 miles of new pipeline and 790 miles of existing natural gas pipelines which would be converted for the transportation of crude oil.

The system would provide delivery of 700 thousand barrels a day (SOHIO's 54 percent share of Prudhoe Bay field production at the rate of 1.2 million barrels per day) to the Port of Long Beach, where the crude would be off-loaded at dockside storage facilities and then transported to an inland storage terminal (Dominguez Hills) about 9 miles distant from the Port facilities. From the inland storage terminal, SOHIO plans to distribute 200 thousand barrels a day of crude oil to local refineries and 500 thousand barrels a day of excess crude oil to Midland through a 90 mile, new 42 inch pipeline to Beaumont, California. At Beaumont the oil would enter a 121 mile, 30 inch converted natural gas line currently belonging to the Southern California Gas Company which would carry it to Desert Center, California, where it would enter a new 42", 39 mile long line pipeline to Ehrenberg, Arizona. From Ehrenberg a new 30", 34 mile long line would connect with another converted 30 inch, 669 mile long gas line currently belonging to the El Paso Natural Gas Company. The El Paso line would transport the crude to Jal, New Mexico where it would enter a new 42 inch, 73 mile long pipeline to Midland (20).

This proposed Valdez to Midland transportation system can provide a means to move North Slope crude, excess to the needs of California, to the Gulf Coast, Midwest, and Great Lakes refining regions. Through utilization of the proposed expansion of the Williams Pipeline System, a scenario put forth by the Federal Energy Administration postulates that the SOHIO crude could be moved from Midland to Tulsa, Oklahoma where it can be transported to refineries near the Northern Tier refineries of Minneapolis/ St. Paul, Minnesota and Superior, Wisconsin (18). Under this scenario, a small diameter pipeline could be extended from Puget Sound terminals to serve the refineries near Billings, Montana (18). These and other changes in the crude supply and product import/export patterns in Montana and North Dakota could assist the Northern Tier refineries in the replacement of their Canadian crude supply (18).

Both the Southern California Gas and El Paso natural gas pipelines have been used for the transmission of natural gas from the Permian Basin in West Texas to California. Both companies have applied for permission (from the California Public Utilities Commission and the Federal Power Commission respectively) to abandon the lines which SOHIO proposes to utilize. Should these lines be abandoned, SOHIO plans to convert them from east to west gas transmission to west to east crude oil transmission. Decision on both applications for abandonment are not expected until the environmental impact statement process has been completed by the Federal Government and the State of California (20).

The conversion of the El Paso Pipeline (one of five presently being used) for oil transmission has caused public concern that such action may preclude the transportation of adequate natural gas supplies to meet future California demand. It has been estimated that the loss of one 30-inch pipeline would reduce the throughput capacity of the Southern California interstate gas network by about 5 percent (36). The pipeline delivery curtailment is a result of rapidly declining supplies of natural gas to California from sources located east of the State boundary. The Bureau of Land Management has indicated that a very unlikely combination of circumstances must occur before the abandoned capacity would be required. These circumstances include (20):

- Total deregulation of wellhead prices for natural gas and the subsequent dedication of interstate reserve additions (those considered highly optimistic);

- Large volumes (400 MMCF/D) of imported LNG being distributed through the Permian Basin; and

- Equally large quantities of Alaskan gas (600 MMCF/D) being distributed through the Permian Basin.

Another area of public concern centers on the potential of further deterioration of a degraded air quality condition in the Los Angeles Basin. At present, temperature inversions occur about 90 percent of the mornings (36). Such a condition, together with low wind speeds, causes entrapment and poor dispersion of pollutants such as oxides of nitrogen and reactive hydrocarbons. The abundant sunshine in this region promotes photochemical reactions of these pollutants which produces ozone, a primary constituent of smog. The SOHIO proposal poses a threat of releasing more pollutants, especially hydrocarbons, into the air during off-loading of oil from tankers, from taking on ballast into cargo tanks, from the engines of tankers and tugboats, and from storage tanks. In order to assure that no "net" increase in air emission will result from this "new stationary source", SOHIO proposes to utilise several mitigating measures which may include the use of low-sulfur fuel, segregated ballast (4 of the 11 tankers carrying SOHIO North Slope crude will carry about 57 percent of normal ballast capacity in segregated tanks; the remaining 7 tankers will carry 100 percent of normal ballast capacity in such tanks), closed inerting systems, exhaust scrubbers, avoidance of purging inside the port, use of vapor recovery systems on storage tanks and, restricting taking on ballast in cargo tanks while in the South Coast Air Basin, use of foam-covering systems to blanket tank spills, oil spill contingency plans, and the abandonment of 33 existing storage tanks (20, 36). A detailed examination of the emissions of pollutants and air quality implications associated with the proposed SOHIO project is presented in the next chapter.

Since the transportation of North Slope oil to Long Beach or any other West Coast port presents the possibility of oil spills, several analyses have been performed to determine the likelihood of their occurrence and extent. These are summarised in the next chapter. With respect to the SOHIO project, the most likely places for accidents resulting in spills are in Prince William Sound and in the Santa Barbara Channel off Southern Californi[illegible]. There is a greater possibility for severe damage to shore along the [illegible]hern part of the route from Valdez to Long Beach as tankers will be traveling closer to shore. The mitigation of these hazards will be addressed in oil spill contingency plans currently being prepared by SOHIO.

Central Alternatives

A centrally located route for the eastward movement of North Slope crude has been under consideration for some time. The West Coast terminus for such a route, conceptually, would be an offshore monobuoy system for offloading. Such a mooring system would be located about 1.5 to 4 miles offshore where water depth is sufficient for large tankers. The offshore buoys would be connected by submarine pipeline to onshore storage and the terminus of a trunk line located inland from the beach and steep foot hills of the coastal range. This alternative would not require extensive dredging and construction, but may result in an increased risk of accidents and oil spills which are difficult to contain over an alternative which includes a protected harbor (36).

Two sites frequently proposed for such a monobuoy system are Estero and San Luis Obispo Bays along the coast of central California. Estero Bay, approximatley 12 miles northwest of San Luis Obispo, contains the entrance to Morro Bay, and important tidal estuary and aesthetic attraction in central California. The proposed site in San Luis Obispo Bay lies south of Avila Beach and west of Pismo Beach.

Oil spills pose a threat to each area. The Morro Bay estuary has a narrow entrance, mostly cutoff from the sea by a sandspit (allowing boom protection to be relatively easy), and Morro Rock. The Bay supports a sports fishery for gaper and Pismo clams and a commercial fishery for Pacific clams. Many rare, endangered, and unique species have inhabited the Bay including the Great Blue Heron, Black Brant, Peregrine Falcon, the endemic Morro Bay kangaroo rat, and Harbor seals. The California Department of Fish and Game has designated Estero Bay as a questionably acceptable site because it is within the protected range of the sea otter and due to the sensitivity of Morrow Bay (36).

The Avila Beach site in San Luis Obispo Bay to the south may be more suitable for marine terminal in that Union Oil already utilizes the area for oil-related activities and land is available for onshore facilities (36). Currently, the California Office of Planning and Research is considering San Luis Obispo Bay as a realistic and reasonable alternative to SOHIO's Long Beach site (37). The Avila Beach area of San Luis Obispo Bay does not have an estuary, but is within the northern range of the California sea otter. The Fish and Game Department has designated the offshore area between Avila Beach and Monterey Bay as the protected range for the sea otter (range includes Estero Bay). The sandy coastline of Avila and Pismo Beach also support a clam fishery (36).

The Avila Beach site has been suggested by the California Air Resources Board as an alternative to SOHIO's Long Beach Terminal (37). The air quality in the area of both Estero and San Luis Obispo Bays generally is good and may be viewed as being a viable alternative site to avoid further degradation of the Los Angeles basin where hydrocarbons are a special problem. However, the project also could impact the downwind areas of Estero or San Luis Obispo Bays which are characterized as being sensitive to inversions and conditions suitable for oxidant formation (36).

Utilizing a monobuoy system off central California, a conceptual pipeline could feed the midcontinent with an eastern terminus at Sidney, Nebraska. Such a pipeline (roughly 1500 miles in length) could pass through the Salinas River, a primary watershed of the central California coastal range and the Los Padres and Tahoe National Forests in California and the Wasatch Range of Utah (36). Another route could be to construct about 100 miles of new pipeline to Redlands, California for connection with the proposed SOHIO pipeline or another pipeline which follows the same route.

An Elk Hills Route

The Naval Petroleum Reserves Production Act of 1976 directed that the production from the Naval Petroleum Reserve No. 1 (Elk Hills) in central California be increased to the maximum efficient rate consistent with sound engineering practices and that pipelines and associated facilities for transportation of the crude be provided to accommodate a minimum of 350 thousand barrels a day within three years (36). By 1980, this new source of oil should be supplying oil at a rate of 200 to 250 thousand barrels a day. While the Act authorizes production through 1982, it is assumed that production will continue at its maximum recovery rate through 1985 (16).

The Navy has identified the following alternatives for the movement of this oil (36, 38):

- A pipeline to Port Hueneme (near Oxnard, California) to tie into a marine terminal for tanker transportation.
- A pipeline to Redlands, California to connect to the proposed SOHIO pipeline.
- A pipeline to Coalinga, California to tie into pipelines serving Getty, Shell, or Standard Oil of California refineries.
- A railroad/truck tank car train system for transport to appropriate marketing facilities.

A tie into the proposed SOHIO pipeline would allow Elk Hills oil to be transported easily to eastern states at relatively low cost. It is possible that Elk Hills oil could be piped to Port Hueneme and moved by tanker or moved directly by rail to San Francisco or Los Angeles at the same time that North Slope oil is brought in by tanker and piped inland. The selection of a central pipeline route for the eastward transport of North Slope crude could provide another opportunity for a hookup from Elk Hills (36). Currently the Navy is accepting bids for crude oil from Elk Hills (no one buyer will receive more than 20%) and is selecting a consulting engineer to design a pipeline (39, 40).

The Elk Hills production plays an important role in estimates of a West Coast surplus of crude oil estimated to be between 300 and 600 thousand barrels a day as early as 1978 (41). One solution to the surplus problem may be to shut down the production from Elk Hills or, as an alternative, retain it within the strategic reserve system (35).

OTHER WEST TO EAST ALTERNATIVES

Tankers/Tank Car Unit Trains

Currently, railroads transport less than one percent of the crude oil within the U.S. Typically, unit trains are composed of 90 tank cars which carry a total of 50 thousand barrels. The spillage of oil and the control and recovery of air pollutant vapors have been adequately maintained. Land use conflicts present a problem in that each railroad terminal site would require an area of one square mile (20).

Several unit train alternatives are being proposed. The most advanced proposal, sponsored by the Burlington Northern Railroad, involves tankers from Valdez to Point Westward, Oregon (or Puget Sound) and unit trains serving Northern Tier refinery centers such as Cut Bank, Montana and Minot, North Dakota, and Clearbrook, Minnesota. Port Westward is an existing port used by the U.S. Army for Far Eastern supply with facilities available for docking ships as large as 35,000 dwt (20). The sponsor claims that an initial volume of 200 thousand barrels a day could be shipped (16).

This concept provides a short term solution to meet the demand for crude by the Northern Tier states and at the same time to partially relieve the West Coast surplus. However, movement of oil by train is expensive - as much as 2 1/2 times the cost of pipeline delivered oil. Refineries are more likely to view the train concept as a last resort. Northern Tier refineries may prefer to receive Indonesian crude by rail than Alaskan crude owing to low sulfur content (16).

Reversal of Four-Corners Pipeline

Another alternative, though not of major significance is to reverse the Four-Corners pipeline which now transports 30 thousand barrels a day from Red Mesa, Utah to Los Angeles, California (42). From the Four-Corners area the pipeline connects with lines which could carry oil to Texas (34). Current projections indicate that the Four-Corners pipeline is likely to be shutdown by [illegible]980 (43). Recently, the Four-Corners line was acquired by the Atlantic Richfield Company (ARCO) which proposes that a modest amount of the West Coast surplus could be fed through the reversal of the Four Corners Pipeline system to satisfy needs of refiners and industrial users in New Mexico and Arizona (44).

Central American Pipeline

Currently there are four pipelines across the Isthmus of Panama which were constructed by the U.S. Navy in the early 1940's (20). Two of them are in use and comprise a total pumping capacity of almost 113 thousand barrels per day. Of the other lines, one (20 inch) was used for diesel fuel and the other (10 inch) was never used. The system was designed for east to west oil movement, but can be reversed. Additional lines would be required in order to transport the expected North Slope West Coast surplus.

At present, any construction for the purpose of utilizing these pipelines for commercial activity would be in violation of the 1936 U.S. treaty with Panama. Should current negotiations with the Republic of Panama concerning the future status of the Canal Zone include operation of the pipelines by a Panamanian corporation, the alternative for commercial lease of the lines is within the scope of the 1936 treaty (20)

Several routes have been suggested periodically, for the construction of a pipeline across Central America. These include the countries of Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, and Panama (36). Recent attention has focused on a proposed port on the Pacific Ocean near Las Lisas, Guatemala with a proposed 227 mile, 42 inch pipeline extending to San Francisco del Mar on the Caribbean Sea. The initial capacity of the pipeline is envisioned to be 600 thousand barrels a day with construction completed 24 months after finalization of permits. The eventual capacity could be as high as 1.6 million barrels per day. The sponsor is the Central American Pipeline Company (16). Such pipelines would utilize deepwater terminals on the Pacific sides to accomodate very large tankers (in excess of 250,000 dwt). The Caribbean ports would probably use small tankers to serve the Gulf Coast.

The main issues relating to the construction of a Trans-Central-American pipeline include a degree of security which is somewhat less than that offered by a U.S. point-of-entry and a U.S. pipeline (36), and the consideration of the Trans-Alaska Pipeline Act which urges the use of a domestic transportation system rather than one in or through a foreign country (20).

Around the Horn

Another possibility for the west to east movement of North Slope oil would be to use very large tankers traveling around Cape Horn. Such was the marine transportation route for west coast/east coast trade prior to construction of the Panama Canal. This route is still used by ships too large for the Canal. Currenty, a number of these large U.S. supertankers are available or on order but are subsidized when used in foreign trade. The subsidies would have to be repaid for the ships to qualify for domestic trade under the Jones Act (see the next chapter).

The 15,730 nautical mile distance from Valdez to Gulf Coast terminals presents a need for a system of weather prediction and navigational aids to reduce the risk of accidents in the unfavorable weather and ocean conditions near Cape Horn. No U.S. ports can handle such large tankers at the present time (LOOP and SEADOCK would allow direct importation by 1980 at the earliest). The crude would need to be transferred onto smaller vessels for import as crude or as bulk product after refinement in the Caribbean islands (36).

Available data indicate that the total cost per barrel by the around the Horn trip would be about twice the cost of a route similar to the SOHIO proposal. A large amount of capital would be required for the construction of a fleet of very large tankers for the movement of 500 thousand barrels per day of crude ($2.5 billion). During the round trip from Valdez to the Gulf Coast, a 225,000 dwt tanker would consume one barrel of bunker fuel for every 15 barrels transported - approximately 7.4 percent of the energy delivered (36). This option may be a viable, but costly, method for the short term movement of part of the West Coast crude excess until a long term, less energy consuming alternative can be found.

LOOP-SEADOCK

Two offshore deepwater crude import terminals have been proposed for the Louisiana and Texas Gulf Coast (Figure 10). The Louisiana Offshore Oil Port (LOOP) would provide crude oil flow from St. James, Louisiana through the Capline pipeline system to the Great Lakes region. SEADOCK would provide crude flow from the Houston area through Texoma, Seaway, and Explorer pipelines to Tulsa and Chicago. From Tulsa, the crude could also enter the proposed Williams expanded system (18). Thus, North Slope crude could be transported by 1980 through SEADOCK and LOOP to be distributed to midwest and northern refineries. The total capacity of the terminals will be about 3.5 and 4.0 million barrels per day by 1980 and 1985 respectively. North Slope crude transported by the Cape Horn, new Central indirectly through crude exchanges could displace a portion of the expected foreign imports. These deepwater terminals provide for west to east movement of crude, but rely largely on various schemes of tanker traffic which may entail a higher oil spill risk over a land based pipeline system. Also, their use as an alternative for supplying crude to the Northern Tier states would require supplying Washington, Montana, and North Dakota by another means (18). Should the SOHIO crude vie with crude from SEADOCK for available capacity in the Williams pipeline or similar lines, capacity of these distribution lines may need to be increased.

OTHER SOLUTIONS

Reduced Production of Alaskan Reserves

There will be a period of many months between the projected time that the Trans-Alaska Pipeline will flow at 1.2 million barrels a day in 1978, and thus exceed the rate of West Coast consumption, and the time that the earliest of the Trans-Continental Pipeline projects will be completed. Thus, if the North Slope crude is shipped to the West Coast during this period at a rate not greater than the demand, there would be no West Coast surplus. Actually if Alaskan oil reserves were continued to be conserved by reducing production at or below the level of West Coast demand, projects such as the SOHIO proposal apparently would not be needed. However, the West Coast surplus merely represents an excess existant only in one area of the country. The following are several factors mentioned at public meetings as worthy of consideration before a reduction in the production of Alaskan reserves is undertaken:

- The problem of providing a new crude oil supply to the Northern Tier states may not be easily remedied without the availability of the excess North Slope Crude.
- The Trans-Alaska Pipeline represents a substantial commitment in both capital and to the nation's energy policy and thus should be allowed to reach its fullest potential as soon as possible.
- The leasing program for the Alaskan Outer Continental Shelf is proceeding rapidly, increasing further the production potential as well as that from West Coast offshore deposits.
- Without the benefit of full production from these areas, even at the cost of higher priced short term alternatives, the country would have a still greater reliance on foreign imports.
- As some imports would not be displaced by Alaskan oil entering the U.S. in modern tankers and marine terminals, the likelihood of tanker accidents, similar to those which recently have received public attention, would be higher than that which could be attained utilizing an all U.S. tanker fleet.

demand was recently summarized by Senator Stevens (45):

> The expected surplus of crude oil on the West Coast is not the disaster that some would like to call it. Any domestic supply of oil which can displace foreign imports and their attendant political volatility is a national asset.
>
> Our task now, recognizing that things have changed since our earlier decision, is to determine what systems can be installed most quickly and most inexpensively to affect the most economical distribution of the benefits of Alaskan oil throughout the rest of the nation. And, after making that determination, we need to take the necessary steps to assure that these systems are implemented in a timely manner.

The shutting in of a portion of the North Slope production would be a matter of Presidential commitment and national policy (36).

Strategic Storage

One alternative to the immediate transfer of the crude surplus to eastern markets would be its strategic storage on the West Coast. Such action would be consistent with the goals of the Strategic Petroleum Reserve System as established by the Energy Policy and Conservation Act (PL94-163). Under the Act, the Federal Energy Administration plans to have 150 and 500 million barrels of petroleum in underground (salt domes and in salt or limestone mines) storage by December 1980 and 1982 respectively (46). In the event that suitable storage locations were found, should the reserves be required, the North Slope crude stored near a West Coast port of entry would still be remote from the eastern areas which would have a maximum need. Some method for moving the crude to mid-continent demand centers would still be required.

Enhancement of West Coast Consumption

An alternative to decreasing the West Coast supply and thus the excess of North Slope crude is to increase the demand to the extent that the entire production from Alaskan fields would be consumed on the West Coast. Such a demand would need to exist over the next 20 years to keep ahead of projected North Slope production. Meanwhile, some amount of light and low sulfur crudes would still be required to meet the needs of existing refineries. The increased crude usage probably would result in the establishment of a substantial refined product export industry (36). This large petrochemical processing industry would result in further air quality impacts as well as land consumption and water quality impacts.

The feasibility of this option is limited by the length of time needed to convert the present energy economy and industry. A substantial capital investment is required for such conversion. Since it is unlikely that a significant increase in West Coast demand could materialize in less than a decade, it is unlikely that the West Coast can absorb the projected surplus by 1978 or soon after (36).

SUMMARY COMPARISON

A summary of the highlights of this chapter is presented in Figure 12. The short-term options for handling the projected West Coast surplus of North Slope crude include international exchanges, trans-shipment through the Panama Canal, transport by railroad, transport by tanker around Cape Horn, Canadian exchanges (from present imports) to offset crude curtailments to the Northern Tier states, reduced North Slope production, or possibly strategic storage. By the end of 1978 at the earliest and probably in 1979 more permanent long term solutions could be realized in the form of the Trans-Provincial Pipeline, Trans-Mountain Pipeline, Williams Pipeline, Minnesota Pipeline, and the SOHIO pipeline. By the end of 1979 or during 1980 the Northern Tier Pipeline could be realized as well as a pipeline across Central America. On line in 1981 could be the deep-water ports of LOOP and SEADOCK, the reversal of the Four Corners Pipeline, and perhaps an equitable balance between crude oil supply and demand on the West Coast. The following chapter will address the environmental issues which have received the most visibility and attracted the attention of state and local governments when weighing the major West to East alternatives for the movement of North Slope crude. These issues are the potential for air quality impacts and oil spills.

	Trans-Provincial Pipeline	Canadian Exchanges	Trans-Mountain Pipeline	Williams Pipeline	Minnesota Pipeline	Northern Tier Pipeline	International Exchanges	Panama Canal	SOHIO Pipeline	Central West Coast Alternative	Tanker-Tank Car	Reversal of Four Corners	Central American Pipeline	Around Cape Horn	LOOP-SEADOCK	Reduced Production	Strategic Storage	Increased Demand
On Time in 1977*		▨					▨	▨			▨			▨		▨	▨	
On Time in 1978*	▨		▨	▨	▨				▨									
On Time in 1979*						▨							▨					
On Time in 1981*												▨			▨			▨
On Time after 1981**										▨								
Supply to Northern Tier States	▨	▨	▨	▨	▨	▨					▨							
Partial Solution		▨		▨	▨						▨	▨				▨	▨	▨
International Agreement Required	▨	▨	▨				▨	▨					▨					

* Assuming start of construction at earliest expected date.

** The Central Alternative currently has no sponsors. No detailed studies have been undertaken.

FIGURE 12

SUMMARY COMPARISON OF ALTERNATIVES FOR THE WEST TO EAST MOVEMENT OF NORTH SLOPE CRUDE

SECTION 3

ENVIRONMENTAL ISSUES RELATED TO THE MOVEMENT OF NORTH SLOPE OIL

QUANTITATIVE ANALYSIS OF AIR QUALITY ISSUES

This section presents the results of studies that have been performed with respect to air quality effects due to the transportation of Alaskan oil. The section is relatively detailed and contains various tables and discussions that are useful in comparing emissions and air quality modeling analyses to clarify reasons why a wide range of conclusions and results have occurred. A summary at the end of the section has been provided for those readers interested in only the main technical issues of this complex environmental area.

In the event that one of the west coast port alternatives is chosen as the prime entry point for Alaskan crude, the air quality issues center on the relative impact that large crude oil tanker arrivals and the presence of crude oil storage tank facilities will have in the immediate port area and its associated air basin. Along the Washington, Oregon, and Northern California coasts the issue is one of possible degradation of ambient air quality in areas that, except for some Puget Sound port locations, are currently meeting state and federal air quality standards. For the southern California alternatives, and specifically the Port of Long Beach (PLB), the issue is one of possible degradation of air quality at a time when extensive efforts are being made to bring poor air quality to within state and national air quality standards. Several studies have been performed to date that deal in part, or entirely with, air quality issues and the transportation of Alaskan oil. Most of these studies have been primarily oriented towards evaluating the SOHIO/Port of Long Beach alternative. Table 1 contains a reference list of the source documents used in the following air quality discussion.

Mechanisms for Controlling Air Quality

The Clean Air Act of 1970 (and subsequent amendments) is the basic authority for the national air pollution control program. This act authorizes EPA to set the National Ambient Air Quality Standards (NAAQS) which are the allowable levels of pollutants necessary to protect public health (primary standards) and welfare (secondary standards). Standards have been set for total suspended particulates (TSP), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), photochemical oxidants (O_x),

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TABLE 1

REFERENCED
AIR QUALITY RELATED STUDIES RELATIVE TO
THE TRANSPORTATION AND DISPOSITION OF ALASKAN OIL

16. Federal Energy Administration. 1976. An Analysis of the Alternatives Available for the Transportation and Disposition of Alaskan North Slope Crude. Final Draft Report Dated November 30, 1976. Washington, D.C. 891 pp.

20. Bureau of Land Management. 1976. Draft Environmental Impact Statement, Crude Oil Transportation System: Valdez, Alaska to Midland, Texas (As Proposed by SOHIO Transportation Company. Department of the Interior, Washington, D.C.

26. Northern Tier Pipeline Company. 1976. Supplement Number 2 to the Northern Tier Pipeline Company's Application for Site Certification. Submitted to the Washington State Energy Facility Site Evaluation Council on November 19, 1976.

36. Port of Long Beach and the California Public Utilities Commission 1976 Draft Environmental Import Report: SOHIO West Coast to Mid-Continent Pipeline Project. September 1976.

43. Nehring, Richard. 1976. Mitigating and Offsetting Emissions from West-East Oil Movement. Draft Working Note Dated December 21, 1976. Rand Corporation, Santa Monica, California, 34 pp.

47. Pacific Environmental Services, Inc. 1976. Final Report-Air Quality Analysis of the Unloading of Alaskan Crude Oil at California Piers. Prepared for the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.

48. SOHIO Transportation Company. 1976. Impact of the SOHIO Project on Air Emissions in the Long Beach Port Area. Report Dated August 20, 1976. Midland Building, Cleveland, Ohio.

49. Teknekron, Inc. 1976. Air Quality Impact Evaluation of Candidates Sites for an Alaskan Oil Transfer Terminal in the Pacific Northwest. Draft Report Dated July 31, 1976, Submitted to Region X, U.S. Environmental Protection Agency, Seattle, Washington.

50. Chicago Bridge & Iron Company. 1976. SOHIO/CBI Floating Roof Emission Test Program. Final Report Dated November 18, 1976, Oak Brook, Illinois.

51. MacKenzie, John R. and Charles T. Ran. 1976. Gaseous Hydrocarbon Emissions During the Loading of Marine Vessels. Paper Presented at the 69th Annual Meeting of the Air Pollution Control Association, Portland, Oregon. June 27-July 1, 1976.

TABLE 1 (Continued)

52. U.S. Coast Guard. 1974. Final Environmental Impact Statement-Regulations for Tank Vessels Engaged in the Carriage of Oil in Domestic Trade. Department of Transportation, Washington, D.C.

53. Office of Air and Waste Management. 1975. Compilation of Air Pollutant Emission Factors. (2nd Edition) AP-42. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

54. Esso Research and Engineering Company. 1974. Survey of Ship Discharges. Final Report on Task I, Sub-Task 2 (Contract No. C-1-35049). Prepared for the Office of Research and Development Maritime Administration, U.S. Department of Commerce, Washington, D.C.

55. American Petroleum Institute. 1962. API Bulletin on Evaporation Loss from Floating-Roof Tanks. (API Bulletin 2517). Washington, D.C.

75. Nehring, Richard. 1977. Mitigating and Offsetting Emissions from West-East Oil Movement. WN-9719-CEQ. February, 1977. Rand Corporation, Santa Monica, California, 57 pp.

76. Air Resources Board, State of California. 1977. "Preliminary Analysis of the Proposed SOHIO Marine Terminal at the Port of Long Beach. SS-76-035. December 16, 1977. Sacramento, California.

77. SOHIO Transportation Company. 1977. "Supporting Information for the SOHIO Permit Application Prepared for the Southern California Air Quality Management District." February, 1977. SOHIO Transportation Company, Cleveland, Ohio.

78. Port of Long Beach. 1977. "Overview SOHIO-West Coast to Mid-Continent Pipeline Project." January, 1977. Environmental Affairs Division, Port of Long Beach," California.

79. Office of Planning and Research, State of California. 1976. "Is San Luis Obispo Bay a Realistic Alternative Meriting Further Study if the SOHIO Proposal for a Deepwater Terminal to Receive Alaskan Oil at Long Beach Fails to Meet Prescribed Environmental Standards?", October 28, 1976. Sacramento, California.

and hydrocarbons (HC). Table 2 summarizes the relationship between the above pollutants and various potential emission sources associated with the transportation and disposition of Alaskan oil.* Table 3 contains a summary of current Federal air quality standards and State standards set by California and Washington.

The Federal government controls, by emissions standards, pollutants from new motor vehicles, certain newly constructed industrial sources, and sources emitting hazardous pollutants. With respect to Alaskan oil, regulations on new storage tank facilities and, indirectly, controls on certain oil refinery processes are the principal emissions regulations that apply at this time. However, air quality standards, the concept of Air Quality Maintenance Areas (AQMA), and new source reviews currently being promulgated may have a significant impact on (1) where a port facility will be located, (2) constraints on ships which may call at the facility, and (3) the operating procedures to be allowed (e.g., simultaneous offloading of two or more tankers, purging, etc.).

The AQMA concept is designed to protect growth areas, especially most Standard Metropolitan Statistical Areas (SMSA), from future violations of the NAAQS by requiring states to submit plans on how future emissions growth (and thus air quality) will be controlled. The most uncertain part of this concept is the rate at which economically viable technological advances in air pollution controls can offset the potential emissions due to growth. Due to this uncertainty, current EPA proposed guidelines (72) call for a review of new major projects with a criteria for permit approval that is dependent on emissions "tradeoffs". These tradeoffs would have the affect of substituting new low polluting equivalent facilities for older facilities (thus reducing emissions), or allowing growth of new facilities having an emissions output less than those of replaced older facilities. While the EPA guidelines are proposed, the State of California, and specifically the South Coast Air Quality Management District (SCAQMD) has adopted this type of policy and has explicity included "...those (emissions) that result from the operation of the carriers' engines; the purging or other method of venting of vapors; and from the loading, unloading, storage, processing, and the transfer of cargo." Further, the SCAQMD rules limit emissions of NO_x, HC, and SO_x from new and modified sources to 15 pounds/hour or 150 pounds/day unless it can be shown that best available technology has been used. Emissions of NO_x, HC, and SO_x may not exceed 25 pounds/hour or 250 pounds/day if it is determined that such emissions would cause violations of, or interfere with the attainment or maintenance of air quality standards. An exemption to the above would be allowed only if a stationary source with higher emissions rate is replaced at the same location.

The legal authority for controlling air emissions in port and once a tanker is underway has become an important issue. The placing of constraints

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*Analyses have indicated that CO and particulate emissions due to Alaskan oil transportation are not major and therefore are not discussed in this report.

TABLE 2

PRIMARY POLLUTANTS EMITTED BY PROJECT

Related Sources

	Pollutant Species		
SOURCE DESCRIPTION	HC	NO_x	SO_2
Oil Storage Tanks	X		
Tankship Operations	X	X	X
Construction Equipment	X	X	X
Oil Spills	X		
Oil Refining	X	X	X
Power Generation		X	X

Source: BLM(36)

TABLE 3

AMBIENT AIR QUALITY STANDARDS (PPM)

POLLUTANT	AVERAGING TIME	NATIONAL STANDARDS[2]		CALIFORNIA[1]	WASHINGTON[3]
		PRIMARY	SECONDARY		
Oxidant (Ozone)	1 Hour	.08	.08	.10	.08
Carbon Monoxide	12 Hour	--	--	10	--
	8 Hour	9	9		9
	1 Hour	35	35	40	35
Nitrogen Dioxide	Annual[4]	.05	.05	--	.05
	1 Hour	--	--	.25	--
Sulfur Dioxide	Annual[4]	.03	--	--	.02
	24 Hours	.14	--	.04[5]	.10
	3 Hours	--	.50	--	--
	1 Hour	--	--	.5	.40
	1 Hour (twice in 7 days)	--	--	--	.25
Suspended Particulates	Annual[4] (Geometric Mean)	75 Mg/m^3	60 Mg/m^3	60 Mg/m^3	60 Mg/m^3
	24 Hour	260 Mg/m^3	150 Mg/m^3	100 Mg/m^3	150 Mg/m^3
Sulfates	24 Hour	--	--	25 Mg/m^3	--
Hydrogen Sulfide	1 Hour	--	--	.03	--
Hydrocarbons (Corrected for Methane)	3 Hour	.24	.24	--	.24

1 California values are not to be met or exceeded.
2 National Standards are not to be exceeded more than once/year.
3 Washington values are not to be exceeded more than once/year.
4 Annual Standards are not to be met or exceeded.
5 This Standard is under litigation and not currently enforced.

or allowable operations while in port may be difficult due to the common carrier status of a port facility (e.g. tankers unable to meet the constraint requirements would not use the facility). After getting underway, the tanker captain, Coast Guard, Environmental Protection Agency, and/or the local or state agency may each have varying authority over operations. Current statutes are not explicit as to where legal responsibility for underway tanker emissions lie and no explicit limiting regulations exist. In California, this lack of explicit legal authority is a key factor in the evaluation of the proposed SOHIO project in the Port of Long Beach (76).

Existing Air Quality

Evaluation of the significance of air pollution effects with respect to proposed port facilities located in Puget Sound, central California, and Los Angeles-Long Beach cannot be done without considering existing air quality. The following section, summarized from Reference 75, describes air quality conditions at the these alternative port locations.

> Air quality along the Pacific coast at the three principal candidate port locations varies widely. Table 6 provides a few indicators of these differences. The Table provides 1975 air quality data for selected pollutants at several monitoring stations within each of the candidate port air basins. The pollutants selected are those which will either be emitted from a west-east oil transport system or oxidants created from these emissions. The stations selected in the South Coast Air Basin (Los Angeles-Long Beach) were the one nearest the proposed tanker terminal (Long Beach) and those in a variety of locations downwind from the proposed terminal. The stations selected are downwind from the terminal 55 percent of the year in the middle of the morning, and 80 percent of the year in the middle of the afternoon. During the periods of heaviest pollution, they are downwind from the terminal 90 percent of the time during the middle of the day.
>
> Because neither of the other two locations of proposed port facilities have major pollution problems, air quality data are not as readily available. Within central California, Santa Maria is the closest monitoring site to a proposed terminal located in south or central San Luis Obispo Bay. San Luis Obispo, in the Los Osos Valley, is a monitoring point twenty miles north of the proposed terminal. The four monitoring sites in the Puget Sound/Northwest Basin are dispersed throughout the area of the Sound and provide an indication of maximum pollution levels in the area. Extensive data for locations nearer proposed Puget Sound Ports e.g., March Point or Cherry Point, could not be obtained.
>
> Pollution in the South Coast Air Basin is severe. Federal primary standards for oxidants (0.08 ppm averaged over one hour) are exceeded over a broad area during 80 to 90 percent of the days from May through October and 15 to 36 percent of the days from November through April. State standards for nitrogen dioxide

TABLE 4

SELECTED AIR QUALITY DATA FOR THE SOUTH COAST, SOUTH CENTRAL COAST, AND PUGET SOUND-NORTHWEST AIR BASINS, 1977

	Oxidant (Ozone)			Sulfur Dioxide					Nitrogen Dioxide		
Air Basin Monitoring Station	# Days ≥ Std. >0.08 PPM	# Hours >0.08 PPM	1 Hr. Max (PPM)	Annual Average (PPM)	24-Hr. Max (PPM)	# Days ≥ Std. >[illegible] PPM	# Hours >[illegible] PPM	Daily Max. 1 Hr. Mean (PPM)	Annual Average (PPM)	# Days ≥ Std. >0.25 PPM	Daily Max. 1 Hr. Mean (PPM)
South Coast											
Long Beach	[illegible]	23	0.24	[illegible]	0.08	0	0	0.23	[illegible]	23	0.40
Los Angeles-Downtown	[illegible]	[illegible]	0.25	[illegible]	0.08	0	0	0.14	[illegible]	38	0.39
Pasadena-Walnut	[illegible]	[illegible]	0.32	[illegible]	0.04	0	0	0.07	[illegible]	35	0.49
Pomona	[illegible]	[illegible]	[illegible]	[illegible]	0.04	0	0	0.09	[illegible]	22	0.38
Riverside-Rubidoux	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0.08	[illegible]	[illegible]	0.22
Upland-ARB	[illegible]	[illegible]	[illegible]	N.A.	N.A.	N.A.	N.A.	N.A.	[illegible]	[illegible]	[illegible]
South Central Coast											
San Luis Obispo	[illegible]	[illegible]	[illegible]	N.A.	N.A.	N.A.	N.A.	N.A.	[illegible]	0	[illegible]
Santa Maria[1]	0	0	[illegible][2]	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Puget Sound-Northwest											
Bellingham, [illegible]	0	0	[illegible][2]	[illegible]	[illegible]	0	0	[illegible]	N.A.	N.A.	N.A.
Everett, Medical-Dental	N.A.	N.A.	N.A.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N.A.	N.A.	N.A.
Seattle, Duwamish	0	0	[illegible][2]	[illegible]	[illegible]	0	[illegible]	[illegible]	N.A.	N.A.	N.A.
Tacoma, Hess Building	[illegible]	[illegible]	[illegible][2]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N.A.	N.A.	N.A.

Source: [illegible]

Key: PPM = parts per million

---

[1] October to December only.

[2] Ozone.

(0.25 ppm average over one hour) are exceeded 5 to 10 percent of the days of the year. National primary standards for NO_2 (5.0 pphm annual average) are also exceeded in many parts of the basin. National carbon monoxide standards (9 ppm averaged over eight hours) are exceeded on as many as 20 percent of the days at some locations. State standards for suspended particulate matter (100 micrograms/m^3 averaged over 24 hours) are exceeded more than half the days of the year at some locations, often by large margins. Although state one hour standards for sulfur dioxide are rarely exceeded, state 24-hour standards (0.04 ppm) have been exceeded in the South Coast Air Basin. The national annual average standard has not been exceeded at any location in recent years. State 24-hour sulfate standards (25 micrograms/m^3) are exceeded frequently at some locations.

In the San Luis Obispo Bay area, standards are exceeded infrequently and only by small margins. Oxidant standards are occasionally exceeded at San Luis Obispo. Nitrogen dioxide standards are met by considerable margins. Carbon monoxide and sulfur dioxide standards are also not exceeded. State standards (24-hour averages) for suspended particulates are exceeded occasionally in Santa Maria, most likely because of wind-blown dust.

Air quality problems in the Puget Sound/Northwest Air Basins are also minor. Because of the cooler, cloudier weather and a relative paucity of sources, oxidants, nitrogen oxides and hydrocarbons are not significant. Ozone standards are exceeded only at some locations by small margins at infrequent intervals. Sulfur dioxide is a minor problem. State and Federal secondary standards for suspended particulates are exceeded infrequently in some cities and metropolitan areas (including one location in Port Angeles). Carbon monoxide standards are exceeded at some locations in the Seattle and Tacoma metropolitan areas.

Quantitative Measurement of the Issues

An objective evaluation of the air quality impact of any of the proposed alternative port facilities involves quantifying anticipated project emissions and relating them to their impact on resultant air quality. A generic description of the analysis approach is illustrated in Figure 13 in which each box represents a source of uncertainty that can affect the conclusions about the acceptability of the new emissions sources.

Two measures of impact are indicated. First, emissions inventories can be calculated with and without the new sources in order to identify the magnitude of the problem and indicate future growth. With the "tradeoff" criteria possibly becoming a policy for evaluating new source acceptance, the most accurate emissions calculations obtainable are needed since the calculations will likely be involved with permit and regulatory proceedings. Second, because emissions growth does necessarily cause violations of

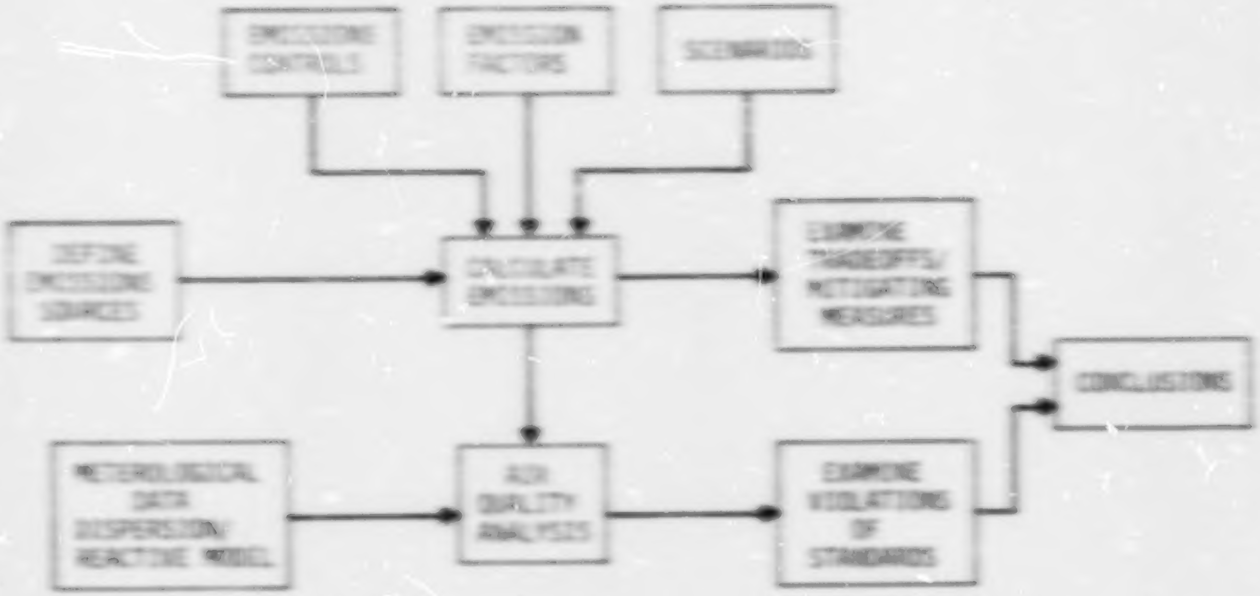
EMISSIONS CONTROLS
EMISSION FACTORS
SCENARIOS
DEFINE EMISSIONS SOURCES
CALCULATE EMISSIONS
EXAMINE TRADEOFFS/ MITIGATING MEASURES
CONCLUSIONS
METEROLOGICAL DATA DISPERSION/ REACTIVE MODEL
AIR QUALITY ANALYSIS
EXAMINE VIOLATIONS OF STANDARDS

FIGURE 13

AIR QUALITY QUANTITATIVE ANALYSIS

ambient air quality standards, an analysis is required to evaluate the effects that meteorological conditions and pollutant reactivities have on resultant air quality. As will be seen, the quantification of the problem to date has been, with respect to either measure, difficult due to differing assumptions concerning tanker fleets, the operations that can and/or will be performed in port, and the adequacy of analytical models to reflect the emission/air quality relationship.

Project Related Emissions Sources

Before a quantitative analysis of air quality effects can be performed, it is necessary to define (and agree upon) project related emission sources. Table 2 identifies the most reasonable set of sources that can be directly attributed to a new tanker port facility and an accompanying pipeline. Of these, oil storage tanks and tankers have the greatest impact. Accidental oil spills, if large and near land, would have a significant short term impact on air quality with respect to evaporative hydrocarbons. However, the expected frequency of such an occurance is small enough to preclude its consideration as a "worst case" emissions source (but, of course, constitutes a very real and more long lasting water pollution hazard). Electrical generation as an explicit pollutant source could have an impact at remote locally powered pipeline pumping stations in areas with little or no current emissions (e.g., the desert). An indirect air quality impact of a proposed marine terminal and pipeline would be oxides of sulfur and nitrogen from fossil fuel powered electrical generation plants. In the Pacific Northwest this will be minimal since electrical power is obtained principally from hydro-electric plants. It has been estimated that from 1300-4600 pounds/day of sulfur oxides (SO_x) and 700-2500 pounds/day of oxides of nitrogen (NO_x) emissions may be associated with the generation of power for the SOHIO project (36,76). Since it would not be possible to attribute these emissions to any one plant in a power grid, air quality impact studies due to a marine terminal/pipeline project would be impossible. However, for the purposes of "emissions tradeoffs" it is likely that these emissions would be included in the overall emissions "balance sheet."

In addition to the sources indicated in Table 2 non-project related emissions within the local environment must be considered. HC and NO are both reactive pollutants and their affect on air quality (specifically O_3 generation) is dependent on the local emissions. Therefore, emissions from local area (e.g., mobile) sources and large point sources (e.g., refineries and power plants) must be considered as well.

Emissions Controls/Tanker and Storage Design

The primary emissions controls involve basic design features built into tankers and storage facilities. In tankers segregated ballast, separate fuel storage tanks for burning low sulfur fuel, and inerting systems that suppress cargo tank emissions and reduce the presence of explosive conditions are the main controls used to reduce emissions. Floating roof designs with double seals and vapor recovery systems are the principal design practice used to reduce fixed storage emissions.

Ballasting--

After discharging cargo, an oil tanker without sufficient segregated ballast capacity will take some sea water aboard in cargo tanks to ensure proper propeller immersion and to provide stability and sea-worthy characteristics. The amount of ballast taken aboard depends upon the anticipated weather conditions, the distance and route of the ballast voyage, the vessel's lightship displacement (weight), length to depth ratio, and other vessel characteristics. The amount of ballast taken aboard in port varies from 15 to 20 percent of the vessel's total cargo carrying capacity, but may be greater during periods of severe bad weather (52).

Tankers currently in trade and under construction can take on ballast in three alternative configurations:

1. All of the necessary ballast is taken on in cargo tanks (with the minor exception of fore and aft peak tanks).

2. A portion of the necessary ballast is taken on in segregated ballast tanks, and the remainder is taken into cargo tanks.

3. All the necessary ballast is taken on in segregated ballast tanks.

The main advantages of having segregated ballast compartments on tankers is that of eliminating the need to discharge oil contaminated ballast water to the environment and reducing potential cargo loss as the result of a collision and/or grounding (depending on the location of the segregated ballast compartment). A secondary advantage is that hydrocarbon vapors present in an unloaded cargo tank need not be vented to the atmosphere due to displacement by the loading of ballast water into the cargo tank. The majority of Alaskan trade tankers will have sufficient segregated ballast to leave port (155) and new vessels* of 70,000 dwt or more will have fully segregated (approximately 35 percent of the dead weight tonnage) ballast facilities (52). This is a U.S. Coast Guard requirement in compliance with amendments to the Ports and Waterways Safety Act of 1972. The Inter Governmental Maritime Consultive Organization (IMCO) has also passed a similiar requirement (76). The majority of the tankers in world trade currently do not have 15-20 percent segregated ballast tanks; thus ballasting currently is largely accomplished in cargo tanks in port (52).

Separate low sulfur fuel storage--

Sulfur oxide emissions are a direct result of fuel combustion in the tanker's boilers. The emission rate is directly proportional to, among other factors, the percent of sulfur in the bunker fuel. In port, during the offloading operation, the tanker boilers are operated at a relatively higher percent capacity in order to pump crude oil off the tankers. This operation, which may run from 10-15 hours, produces significant emissions of sulfur oxides. To offset these high emissions, some of the Alaskan trade tankers will utilize low sulfur (0.5% or less) from special fuel bunkers in port with a resultant 400-600 percent decrease in normal SO_x emissions. The overall affect on total sulfur emissions will depend on the number of vessels calling in port which have separate fuel storage capability.

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* A new vessel, as defined by the Coast Guard, means a U.S. vessel in domestic trade that (a) is constructed under a contract awarded after December 31, 1974; (b) in the absence of a building contract, has the keel laid or is in a similar stage of construction after June 30, 1975; or (c) is delivered after December 31, 1977.

Inerting systems--

As a measure to reduce corrosion in the tanker crude oil storage compartments and reduce the risk of explosion of petroleum gases, the vapor space of the cargo compartments is filled with oxygen poor flue gas from the ships' boiler stacks. The flue gas is washed clean and cooled before delivery to the cargo hold. Approximately 17 percent of the flue gas is diverted from entering the atmosphere in tankers of the 120-165K dwt size which reduces total stack emissions proportionately. During loaded passage the inert atmosphere in the tanks is maintained by periodic repressuring. Upon offloading, as the oil is pumped out of the tanks, inert gas blowers ensure that the tank atmosphere remains inert (oxygen-poor). With proper operating vent control valves and careful monitoring it should be possible to discharge all oil cargo with no release of hydrocarbons to the atmosphere during the entire unloading process.

Once at sea for the return voyage, empty inerted storage tanks may be cleaned to remove oil residues so that clean ballast water can be taken aboard (if necessary), or to prepare the storage tanks for a different cargo type. For those inerted Alaskan trade tankers that will shuttle between Valdez and the west coast and have sufficient segregated ballast, tank cleaning will likely occur infrequently. If the empty inerted tanks make the entire return voyage undisturbed, the inerted hydrocarbon mixture will be vented to the atmosphere through displacement during the crude onloading process at Valdez. Finally, while unlikely, it is possible that due to emergency maintenance requirements, purging of all hydrocarbon emissions (gas freeing) could occur at any time following unloading. In summary, the inerting system acts as a safety measure, reduces tank corrosion, diverts stack emissions to the storage tanks during the unloading process, and minimizes the probability of hydrocarbon emissions in port following unloading.

New Source Performance Standard for Storage Tanks --

The Federal New Source Performance Standards specify that petroleum storage facilities holding 40,000 gallons or greater must have a floating roof, vapor recovery system, or their equivalent when the true vapor pressure is between 1.5 and 11 psia. Since the Alaskan crude vapor pressure is in the 7-9 psia range, any reasonably sized new storage facility will have one of the above features. As will be discussed later, there is a question over the proper formula to use in computing the level of hydrocarbon emissions from new floating roof tank facilities.

Basic Emission Factors

The second step in quantifying port related emissions is establishing a set of basic emission factors. These factors relate to a specific operation associated with the previously identified emission sources and are derived from various sources such as: experimental results, emissions controls, equipment specifications, physical and chemical equations, assumed fuel and crude composition, etc. The sensitivity of the magnitude of the final emissions inventory to the assumed basic emissions factors is great since relatively small differences in the assumed emissions factors propagate into large differences in emissions. Examples of these factors are: fuel sulfur content, crude hydrocarbon composition, fuel consumption rate, combustion gas composition, pumping time, fuel density, etc. Nominal values and the sources for each of these factors are discussed in detail below.

Combustion Pollutants

The tankers delivering crude oil will emit air pollutant products of combustion from their stacks at various rates during their entry into an air basin, maneuvering to dock, "hotelling" at the pier (idling), and during pumping and ballasting operations. The two principal pollutant products will be SO_x and NO_x with lesser amounts of particulates, hydrocarbons, and CO also present. Tankers burn more fuel in berth than other ships as onboard pumps are used to unload the crude in a relatively short time. Combustion products are emitted by assisting tugboats as well but their impact is minimal with respect to the analysis.

Calculation of emissions have been performed in various reports related to the SOHIO project and Alaskan crude transportation in general (16, 31, 36, 43, 44, 77). These reports assume fuel consumption rates for various operations and tanker sizes and then use stack emission factors to generate pollutant emission rates and totals. The methodologies are similar in each report but differing assumptions cause many different values to evolve. The following sections illustrate the values used for calculating SO_x and NO_x hourly emissions.

Oxides of Sulfur--

The basic equation used to calculate SO_x emissions is as follows:

$$E_{ij} = C_{ij} \times \frac{1}{\eta} \times S \times F \times 1$$

where: i = index for tanker type i;

E_{ij} = SO_x stack emissions from tanker type i in operation j (pounds/hour);

j = index of operations tanker type i performs;

C_{ij} = fuel consumption rate for tanker type i during operation j (pounds/gallon);

D = fuel density (pounds/gallon);

S = % sulfur content in fuel;

F = stack emission factor (pounds (SO)/10^3 gallons); and

I = inerting reduction factor.

Except for open sea operations, the maximum hourly emissions were found to occur when the tankers are pumping (offloading) the crude. Table 5 summarizes the values used to calculate SO_2 emissions for pumping operations*.

Not all columns and rows contain values since certain studies did not compute values for all tanker sizes and not all studies contained information on computational assumptions. For "worst case" analyses purposes, BLM is the most conservative since by far the most sensitive factor in Table 5 is the fuel percent sulfur content. BLM also used the lowest fuel density factor (which equates to a higher stack emission factor) and the highest consumption rate. Given that only "best control technology" tankers would be allowed to use a port facility, the single tanker "worst case" is that indicated by the 165K dwt inerted tanker burning .3 %S fuel computed by PES. (The BLM analyses did not apply an inerting reduction factor to their low sulfur burning cases). The 120 pound/hour value is above California state maximum allowable value and would be subject to the previously discussed project acceptance criteria. Subsequent to these studies, the South Coast Air Quality Maintenance District (SCAQMD), SOHIO and the California Air Resources Board (CARB) jointly agreed upon a further set of tanker emissions factors that will likely be used in the evaluation of the SOHIO project permit applications (77). These results are given in the columns labeled "SCD". The principal differences in the emissions factors used in the "SCD" column are due to assumed fuel consumption rates which produce higher emission rates for the 80K dwt tankers and lower emission rates for the 165K dwt tankers than found in the previous studies.

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*In certain cases the reports did not contain explicit values for each column. In these cases, where possible, calculations were performed to "back into" values. Also roundoff errors will cause certain columns to not total properly.

TABLE 5

MAXIMUM HOURLY SO$_2$ EMISSIONS RATES USED BY VARIOUS STUDIES (PUMPING)

Tanker Size (DWT)	Consumption Rate (lbs/hr)						Fuel Density (lbs/gal)					
	FES	BLM	PLB	TER	FEA	SCD	FES	BLM	PLB	TER	FEA	SCD
70K	5320	-	-	5575	-	-	8	-	-	8.2	-	-
80K	7093	7093	-	6336	-	9378	8	7	-	8.2	-	8
80K (inerted)	-	-	-	-	-	9378	-	-	-	-	-	8
120K	12060	12060	-	10755	-	11556	8	7	-	8.2	-	8
120K (inerted)	12060	-	-	10755	-	11556	8	-	-	8.2	-	8
165K (inerted)	14373	14373	13739	12856	-	10150	8	7	7.88	8.2	-	8

Tanker Size (DWT)	Stack Factor (lbs(S%)/10^3 gal)						Inerting Factor (%)					
	FES	BLM	PLB	TER	FEA	SCD	FES	BLM	PLB	TER	FEA	SCD
70K	Every Study Used: 159.5						-	-	-	-	-	-
80K							-	-	-	-	-	-
80K (inerted)							-	-	-	-	.05	.03
120K							-	-	-	-	-	-
120K (inerted)							.05	-	-	.05	.05	.03
165K (inerted)							.03	-	.03	.05	.05	.03

Tanker Size (DWT)	Pounds/Hour (lbs(S%)/hour)					
	FES	BLM	PLB	TER	FEA	SCD
70K	169	-	-	109	109	-
80K	152	160	-	123	151	187
80K (inerted)	-	-	-	-	121	163
120K	250	275	-	209	250	230
120K (inerted)	205	-	-	173	205	200
165K (inerted)	350	322	228	212	260	180

Sulfur Assumptions Used in Analyses:

FES:	.5%	If Separate Fuel Storage;
	2%	Otherwise
BLM:	.5%	If Separate Fuel Storage;
	3%	Otherwise
PLB:	.5%	Only; Other Vessels not Allowed
TER:	1.5%	In All Vessels
FEA:	1.5%	In All Vessels
SCD:	.5%	In All Vessels

Tanker Size/Type	Tanker SO$_2$ Emission (lbs/hr)								
	FES		BLM		PLB	TER	FEA	SCD	
	.5%	2%	.5%	3%	.5%	1.5%	1.5%	.5%	2%
70K	-	218	-	-	-	155	165	-	-
80K	71	285	-	480	-	185	213	95	176
80K (inerted)	-	-	-	-	-	-	182	82	176
120K	-	480	-	825		313	369	115	580
120K (inerted)	102	408	137	-	-	267	306	100	400
165K (inerted)	120	480	161	-	114	318	360	90	360

Sources: FES (57), BLM (30), PLB (36), TER (49), FEA (16), SCD (77)

Even without considering fuel sulfur content, the results display significant variability in computed values. Any computation of emission totals therefore will be sensitive to these hourly rate differences.

Oxides of Nitrogen--

Oxides of nitrogen (NO_x) are a byproduct of combustion both due to reactions with nitrogen contained within the fuel and through high temperature reactions with nitrogen in the air. Since maximum fuel consumption while in port will occur during offloading, maximum hourly NO_x emissions will occur during this operation. The approach to calculating NO_x emissions is similar to that used for SO_x with the exception that none of the analyses consider nitrogen fuel content in the calculations.

Table 6 summarizes results obtained in various reports. Three different stack emission factors were used that reflected a sizable difference in assumed emission rates. The middle value (63.6 pounds $NO_x/10^3$ gallons) used by BLM and FLB was taken from AP-42, the EPA handbook of emissions factors (53). This value reflects full power fuel consumption. The highest value used by PES, Teknekron, and, indirectly, FEA reflect factors given in a study by EXXON Corporation for the Maritime Administrative Office of Research and Development (54). The joint SOHIO, SCAQMD, and CARB (SCD) value was based on emissions test by Scott Environmental Technology, Inc., on an inerted tanker in December, 1976 (77). The resultant stack emission factor was twenty percent less than the AP-42 value and less than half the value in Reference (54).* As with the SO_x calculations, the results give several values for each tanker type. Primarily due to the stack emission factors used, the PES and FEA estimates were the highest and the SCD emissions estimates were the lowest.

Hydrocarbon Emissions From Tankers

Tanker HC emissions evolve from five tanker operations: boiler combustion, ballasting, fueling, venting, and purging. Fueling and boiler combustion HC emissions were found to be negligible in the various studies and will not be considered here. Additional hydrocarbon emissions are a result of losses from fuel storage tanks that would be associated with a port terminal facility. Very few analyses have been performed on the tanker loading emissions at Port Valdez. BLM has indicated that analyses have shown that air quality at Port Valdez will be impacted due to increased tanker traffic (20). Since tanker cargo loading is not anticipated for the Alaskan trade tankers at any point but Port Valdez, all the analyses to date have disregarded this HC source.

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*These results were preliminary and subject to further examination.

TABLE 6

MAXIMUM NO_x EMISSIONS (LBS/HOUR)

Tanker Size (DWT)	Consumption Rate (lbs/hr)						Fuel Density (lbs/gal)					
	PBS	BLM	FLB	TBK	PBA	SCD	PBS	BLM	FLB	TBK	PBA	SCD
70K	5320	–	–	5579	–	–	8	–	–	8.2	–	–
80K	7093	7093	–	6336	–	9378	8	7	–	8.2	–	8
80K (Inerted)	–	–	–	–	–	9378	–	–	–	–	–	8
120K	12040	12040	–	10745	–	11556	8	7	–	8.2	–	8
120K (Inerted)	12040	–	–	10745	–	11556	8	–	–	8.2	–	8
165K (Inerted)	14373	14373	14388	12846	–	10570	8	7	7.88	8.2	–	8

Tanker Size (DWT)	Stack Factor (lbs NO_x/10^3 gal)						Inerting Factor (%)					
	PBS	BLM	FLB	TBK	PBA	SCD	PBS	BLM	FLB	TBK	PBA	SCD
70K	103.8	–	–	103.8	–	–	–	–	–	–	–	–
80K	103.8	61.6	–	103.8	–	48.3	–	–	–	–	–	–
80K (Inerted)	–	–	–	–	–	48.3	–	–	–	–	.85	.87
120K	103.8	61.6	–	103.4	–	48.3	–	–	–	–	–	–
120K (Inerted)	103.8	–	–	103.8	–	48.3	.85	–	–	.85	.85	.87
165K (Inerted)	103.8	61.6	61.6	103.8	–	48.3	.83	–	.83	.85	.85	.87

Tanker Size (DWT)	Pounds NO_x/Hour					
	PBS	BLM	FLB	TBK	PBA	SCD
70K	70	–	–	71	80	–
80K	92	64	–	80	92	57
80K (Inerted)	–	–	–	–	86	49
120K	156	109	–	136	156	70
120K (Inerted)	132	–	–	116	132	58
165K (Inerted)	156	130	96	138	126	54

SOURCES:

PBS (47), BLM (20), FLB (36).

TBK (48), PBA (26), SCD (77).

Differences in "worst case" hourly HC emission estimates have evolved principally due to assumptions about which tanker operations will, or will not, occur in a port during unloading and ballasting operations. Table 7 presents the hourly values reported by the various studies of the issue (16,20,36,47,49,77). As with NO_x and SO_x, considerable differences in values are found between studies. Ranges were used in the PES, FEA, and SCD studies to reflect a range of hydrocarbon densities that might be present in the tanker cargo hold during the assumed operations. In addition the SCD report included in-transit ballast and purging emissions route to Point Conception, or approximately 160 miles from the Port of Long Beach. The BLM report used a ballast emissions factor based upon a report describing cargo tank emissions during loading operations (51). The PLR report used the computations given in EPA-42 (53) for fixed roof storage facilities to estimate venting losses. All studies used a correction factor to reflect reactive hydrocarbons that ranged between 94% to 97%.

The single largest emission source, purging, if performed in port would cause a considerable impact on ozone concentrations in Southern California alternative port locations (16,47). For the proposed Port of Long Beach facility, the applicant (SOHIO) claims that this operation will not be performed in port and the Coast Guard has stated that only tank washing or maintenance activities would warrant tank purging (16). An evaluation of how often unscheduled purging is required has not been performed by any study.

Assuming no purging will be performed in port, the issue becomes one of the magnitude and extent of ballasting emissions. Since it is expected most of the Alaskan trade tankers above 70k dwt will have sufficient segregated ballast to at least leave port, only non-segregated ballast tankers need be considered. The BLM value for these emissions was above the maximum value computed by PES and FEA. If only fully segregated ballast tankers were allowed to use a port facility, no ballast emissions would occur.

If an inerting system is used and/or properly operating vent pressure-vacuum valves are used on tankers then no, or negligible, venting emissions will occur. These emissions are a result of HC evaporation within the tanker storage compartments due to ambient temperature changes and can be controlled by proper valve settings and positive inert gas pressure. Given segregated ballast, inerting, and no purging in port, tanker hydrocarbon emissions will be near zero.

For the SOHIO project, there is an issue as to whether or not HC emissions from tankers after leaving port, but within the Los Angeles area (e.g., to Point Conception), should be considered. These emissions could occur due to continued purging of tanks or from taking on ballast up to the 35 percent dwt level for sea voyage in those tankers with less than 35 percent segregated ballast. The majority of the principal Alaskan crude tankers calling at the proposed SOHIO terminal are projected to have 35 percent segregated ballast. However, as a common carrier facility some question has arisen as to what other types of tankers may use the facility.

TABLE 7

MAXIMUM HC HOURLY EMISSIONS (LBS/HOUR)

Venting (Inerted/Non-Inerted)

Tanker Size	PBS	BLM	PLB[1]	TRR[4]	FEA	SCD
70K	NR/0-350	NR	NR	-	NR/60-158[7]	-
80K	NR/0-400	NR	0/230	-	NR/100-240[7]	0/50[8]; 0/110[9]
120K	0/0-600	NR	0/308	-	0/150-360[7]	0/70[8]; 0/170[9]
165K	0/NR	NR	0/410	-	0/NR	0/100[8]; 0/244[9]

Ballasting (Seg/Non-Seg)

Tanker Size	PBS	BLM	PLB[2]	TRR[4]	FEA	SCD
70K	0/525-1750[3]	2129	NR	-	0/420-1680[7]	-
80K	0-1978[3]/NR	NR	0/1450	-	0/640-2560[7]	0/800[8]; 0/1066[9]
120K	0/NR	NR	0/2175	-	0/NR	0/00[8]; 0/1600[9]
155K	0/NR	NR	0/3000	-	0/NR	0/00[8]; 0/0[9]

Purging (Inerted)

Tanker Size	PBS	BLM	PLB	TRR[4]	FEA	SCD
70K	0	NR	NR	-	NR	-
80K	0	NR	2280	-	NR	2160-3280[7,8]; 1440-2138[7,9]
120K	0-5990	NR	3440	-	2380-6200[5,7]; 3500-8300[6,7]	3240-4920[7,8]; 2160-3282[7,9]
165K	0-8740	NR	4719	-	2820-6780[5,7]; 3500-8430[6,7]	4460-6760[7,8]; 2970-4520[7,9]

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[1] PLB values given on a per visit basis. Assume 10 hours.
[2] PLB values given on a per visit basis. Assume 6 hours.
[3] Low value based on 3% HC concentration. High value based on 10% HC.
[4] Draft report, reference (59), did not contain HC computations.
[5] Purging value based on sequential purging of tanks during first hour.
[6] Purging value based on simultaneous purging of tanks during first hour.
[7] Low value based on 3% HC concentration. High value based on 12% HC.
[8] In port emissions.
[9] In transit to point conception.

Sources: PBS (47), BLM (20), PLB (36), TRR (59), FEA (16), SCD (77).

Hydrocarbon Emissions From Storage Facilities

All studies used the API Bulletin 2517 (55) for computing the emissions from storage facilities associated with a port facility. The results ranged in value from 75-175 pounds/hour given different throughput assumptions, locations, meteorological conditions, and corrections for reactive HC. These emissions, while not as high as some of the maximum tanker operating emissions, are continuous and on a yearly basis will be quite sizable. A recent study on a scale model facility using latest technology indicates that the API Bulletin 2517 formula may overestimate emissions by a factor as high as 300-500% (50). Since the API Bulletin is based upon older technology, the storage emission computations may reflect overestimates.

Project Scenarios and Total Emissions

In general, the newer larger tankers tend to have more emissions controls (e.g., separate ballast, inerting) and therefore, scenarios run to date with larger tankers tend to indicate lower average emissions. Scenarios describing "worst-case" short term (emissions) cases are more dependent on the particular operations assumed. The fleet mix, in these cases, affects the probability that a particular operation will occur. Almost all the analyses to date have emphasized the "worst-case" short term scenarios. However, all the analyses have differed as to what constitutes a valid "worst-case" scenario and what probabilities can be assumed. The probabilities associated with the scenarios should be those that reflect the emissions and air quality standards requirements. For example, hourly National standards should not be violated more frequently than once per year. Therefore the "worst" scenario associated with a chance of occurrence equal to or greater than 2 in 365x24 hours should be considered. For states such as California where no violations are permitted, the relevant probability would be equal to 1 in 365x24 hours.

Tables 5, 6, and 7 previously described the "worst-case" hourly emission on a per tanker basis. Table 8 summarizes the worst case combustion scenarios that have been examined to date, and Table 9 summarizes the fugitive HC emissions scenarios. On an average daily basis the estimates of SO_x emissions range from 362 pounds/day to 11,000 pounds/day. These differences arise from the assumptions made about sulfur content of the fuel burned, the length of stay in port, the number of visits per year, in and out of port distances , and the types of ships in the assumed fleet. The FEA scenarios assumed 24 hour pumping times and 40 hour port visits. The PES scenarios assumed 10-15 hour pumping time and approximately 40 hours in port. Both of these studies also included a sizable emission contribution due to maneuvering to and from berths under power. The ranges on the PES and FEA estimates reflect assumed throughputs of between 500,000 bpd and 1,000,000 bpd. The FLB estimate, based on 700,000 bpd throughput and .55% fuel content, assumed a total SOHIO fleet calling at the Port of Long Beach for an average of 24 hours. The ARB estimates include 190 mile transit emissions between the Port of Long Beach and Point Conception. The SOHIO estimates were those submitted in their application to SCAQMD.

TABLE 8

COMBUSTION POLLUTANTS - SCENARIOS

STUDY	SCENARIO NAME	SO_2 (lbs)	NO_x (lbs)	TIME PERIOD
PLS	Max. 3-165K (.55%)	342	289	1 hour
PLS	Average (.55%)	1,130	600	24 hour average[1]
BLM	Max. 3-120K (35%)	826	-	1 hour
BLM	Max. 3-120k (35%)	2,472	-	3 hour
BLM	Max. 3-120K (35%)	11,370	-	24 hour
PES	Max. 3-165K (25%)	1,624	663	1 hour
PES	Cen. Ca. Offshore (1.55%)	4010-8230	1778-3567	24 hour average[2]
PES	Cen. Ca. Import (1.55%)	4774-8992	2177-4097	24 hour average[2]
PES	Treasure Island (1.55%)	8,360	3,816	24 hour average[2]
PES	So. Ca. Offshore (1.55%)	4019-8021	1805-3557	24 hour average[2]
PES	S. Ca. Import (1.55%)	4092-8064	1844-3630	24 hour average[2]
FEA	Most Probable 2-120K (1.55%)	612	264	1 hour probable
FEA	Average-California Import(1.55%)	8,092	4,097	24 hour average[3]
FEA	Max. 3-165K (1.55%)	1,080	465	1 hour
ABB	Max. 1-120k, 2-165K (includes 190 mi Transit)	11,370	8,780	24 hour
ABB	Max. 2-62k, 1-71K (includes 190 mi Transit)	6,790	3,910	24 hour
ABB	Max. 1-120k, 2-165K (includes 190 mi Transit)	5,760	8,780	24 hour
SOH	Max. 2-165k, 2-165K (.55%)	3,800	2,400	24 hour

[1] PLS Throughput: 700,000 BPD

[2] PES Throughput: 500,000-1,000,000 BPD

[3] FEA Throughput: 500,000-1,000,000 BPD

Source: PLS (36), BLM (20), PES (47), FEA (16), ABB (76), SOH (77)

TABLE V

HYDROCARBON POLLUTANTS - SCENARIOS

STUDY	SCENARIO NAME	HC(lbs)	TIME PERIOD
FLS	All Emissions Average	3,240	24-Hr. Average[1]
BLM	Max. 3-70K Ballasting	6,239	Hourly
PES	Max. 3-165K Purging	25,000	Hourly[3]
PES	Con. Co. Offshore (No Purge)	1,961-6,065	24-Hr. Average[2,3]
PES	Con. Co. Inport (No Purge)	2,739-6,800	24-Hr. Average[2,3]
PES	Treasure Island (No Purge)	1,961-6,215	24-Hr. Average[2,3]
PES	So. Co. Offshore (No Purge)	2,057-6,125	24-Hr. Average[2,3]
PES	So. Co. Inport (No Purge)	2,083-6,172	24-Hr. Average[2,3]
PES	Con. Co. Offshore (Purging)	20,106-31,095	24-Hr. Average[2,3]
PES	Con. Co. Inshore (Purging)	6,866--20,190	24-Hr. Average[2,3]
PES	So. Co. Offshore (Purging)	18,108-29,402	24-Hr. Average[2,3]
PES	So. Co. Inshore (Purging)	18,134-29,449	24-Hr. Average[2,3]
ABS	Max. 1-120K, 2-165K Purging/no Ballasting	184,000	24 Hours
ABS	Max. 2-62K, 1-71K Ballasting	11,100	24 Hours
ABS	Max. 1-120K, 2-165K No Purging/ No Ballasting	6	24 Hours
SUN	Max. No Tanker Emissions	480	24 Hours

[1] FLS Throughput 700,000 BPD

[2] PES Throughput 500,000-1,000,000 BPD

[3] PES 12% HC Concentration Assumption

Sources: FLS (36), BLM (20), PES (67), ABS (76), SUN(77)

The various FES and FEA scenarios displayed relative insensitivity to the port locations considered except for the "central California in-port" scenario. This was due primarily to the increased number of trips assumed necessary to deliver crude at a 500,000 to 1,000,000 bpd rate.

Average NO_x emissions were also forecast to be lower by PLB than by, FEA and FES. Besides the above mentioned differences in assumed calling and pumping times, the hourly NO_x emissions factor used by FEA and FES was approximately 70% higher than that of PLB. The ARB NO_x emissions included the in-transit emissions. The SOHIO estimates reflect the low stack emission factor previously described.

The one-hour SO_2 maximum rates calculated by the different studies differ mainly due to the sulfur content assumed in the fuel. The BLM scenario for the Port of Long Beach assumes all SOHIO tankers would burn .5% fuel and thus utilized three 110K dwt non-SOHIO tankers burning 3% fuel as the "worst case". The maximum 1 hour "worst-case" NO_x emissions ranged from 289 to 563 pound/hour. This difference is entirely due to the difference in assumed stack emissions factors used by PLB and FES/FEA.

The hydrocarbon emissions scenarios resulted in far higher emissions ranges than those due to combustion. This is due to an uncertainty as to what operations will, or will not occur in port. The FES scenarios illustrated in the Table 9 reflect emissions occurring with the worst assumed HC concentrations. The average value calculated by PLB and SOHIO for its application assume minor levels of tanker emissions but included other sources in their HC calculations. The ARB estimate assumes all three tankers would purge within the 24 hours time period at port and in transit to Point Conception. The major difference depicted in Table 9 is that related to the purging assumption. The sensitivity of the overall HC emissions level to this assumption is evident when the FES "with purging" and "without purging" scenarios are examined.

Scenario Probabilities

Scenario probabilities were calculated in the BLM report to relate "worst case" analyses to their chances of occurring during operations at the Port of Long Beach. Table 10 presents the results of these calculations. Case A reflects a "best fleet" configuration; Case B a "worst fleet" configuration; and Case C reflects a fleet expansion from handling 700,000 bpd to 1.2 million bpd. A "best fleet" would have larger vessels with segregated ballast, inerting systems, and low sulfur fuel handling capability than a "worst fleet". Ballasting for HC emissions and pumping for combustion emissions were considered in generating "worst case" hourly emissions (purging was considered to be not allowed in port and therefore had a zero probability of occurrence).

TABLE 10

ANNUAL PROBABILITIES OF OCCURRENCE FOR AIR QUALITY IMPACT SCENARIOS

FLEET CASE	Tanker Description	Oper-ation	Operation Duration (hrs)	Simultaneous Events		
				1	2	3
A	SOHIO 165,000 DWT	P[a]	15	.1531	.0234	.0036
A	SOHIO 165,000 DWT	B[b]	2.2	.0225	$5.06x10^{-4}$	$11.3x10^{-6}$
A	Non-SOHIO 70,000 DWT	P	15	.1225	.0150	.0018
A	Non-SOHIO 70,000 DWT	B	2.2	.0180	$3.23x10^{-4}$	$5.80x10^{-6}$
B	SOHIO 165,000 DWT	P	15	.1400	.0196	.0027
B	SOHIO 165,000 DWT	B	2.2	.0205	$4.22x10^{-4}$	$8.66x10^{-6}$
B	Non-SOHIO 120,000 DWT	P	15	.1100	.0121	.0013
B	Non-SOHIO 120,000 DWT	B	2.2	.0161	$2.60x10^{-4}$	$4.20x10^{-6}$
C	SOHIO 165,000 DWT	P	15	.1596	.0256	.0040
C	SOHIO 165,000 DWT	B	2.2	.0234	$5.48x10^{-4}$	$12.8x10^{-6}$
C	Non-SOHIO 120,000 DWT	P	15	.1250	.0156	.0020
C	Non-SOHIO 120,000 DWT	B	2.2	.0183	$3.36x10^{-4}$	$6.16x10^{-6}$
C	Non-SOHIO 70,000 DWT	P	15	.5088	.2588	.1317
C	Non-SOHIO	B	2.2	.0766	.0058	$4.15x10^{-4}$

Source: BLM (20)

[a] Pumping.

[b] Ballasting.

The probabilities, while indicative of relative outcomes, overestimate the chances of simultaneous events which involve 2 or 3 ships performing operations for at least one hour. This is the relevant probability when considering the effect on one hour air quality concentrations. In addition, Table 10 does not reflect the joint probability with a characteristic set of "worst-case" meteorological conditions. With these caveats, all the 3-ship pumping scenarios exceed the hourly once a year probability of occurrence (1.1×10^{-4}). The "70K dwt worst case" ballasting scenario exceeds the probability of once-a-year occurrence only in the expanded fleet case. The overall conclusions based on these probabilities are that the pumping scenarios for "worst case" conditions (e.g., those used for SO_x and NO_x emissions and air quality assessments) have a reasonable chance of occurring at least once per year and that the HC ballasting "worst-case" scenarios have a less than reasonable chance of occurring.

A study by ARB also evaluated various scenario probabilities (76). Through a queueing model the number of times simultaneous operations would occur for one, two, or three tankers regardless of type was calculated in terms of hours per year. The results were similar to the BLM analysis with the 3 ship (regardless of size) ballasting scenario having a less than 1 in 365x24 probability of occuring, and the 3 ships offloading scenarios very likely exceeding that probability. Future work should be performed to further evaluate emissions probabilities.

Air Quality Modeling Results

The relationship between emissions and resultant air quality is complex and dependent upon many conditions such as emissions height, emissions temperature and velocity, wind speed and direction, terrain topography, etc. In order to relate emissions to predicted air quality levels in a geographic area, various mathematical computer models have been developed. These models are useful in indicating steady state air quality concentrations at points where no actual measurements are available and thus can save the expense of costly on-site monitoring. However, a process of calibration of the model through comparisons with real data at selected geographic locations is desirable to reflect actual conditions at a location. When actual data are not available, as in predicting the effects of a new source, the results may suffer in accuracy.

For pollutants that are relatively "non-reactive" atmospheric dispersion models can be used. These models use wind data, actual air quality measurements, and atmospheric stability curves derived from empirical experiments to mathematically "disperse" emissions and give their contributions to estimated air quality concentrations in the area of interest. Thus, one can quantitatively estimate the incremental contribution to air quality concentration of a project and, alternatively, the incremental decrease in concentrations due to "tradeoffs".

For reactive pollutants, such as HC and NO, models have been developed to describe the concentrations of resultant pollutants such as oxidants in an area through the use of chemical equations and empirical meteorological relationships. These models are used to compute total concentrations and are dependent on a good emissions inventory of the surrounding environment and extensive calibration.

Unfortunately, there is considerable uncertainty associated with the results of either type model. The complex photochemical relationships involving reactive pollutants such as HC and NO are not fully understood and various simplifying assumptions must be made. Further, reactive model validation has usually been carried out over large areas for which principal emissions come from well mixed auto exhausts and other area emissions and elevated stacks. The characteristics of tanker emissions (ballasting, purging, and venting) lie somewhere between the two categories and may be different enough to justify separate model parameters. In addition, factors such as atmospheric stability, changing terrain topography (e.g., water to land or flat to mountainous) and variations in wind direction and speed over time add to result uncertainity, especially over longer averaging peri[illegible]. When combined with the previously discussed emissions inventory uncertainties, it becomes clear that the results obtained from these models must be used cautiously. They do illustrate trends and the relative air quality impact at different locations from project related emissions and should be analyzed with this perspective.

Atmospheric pollution models are very sensitive to assumed meteorological conditions. Two short-term conditions tend to cause high ground concentrations to develop from plumes of elevated emissions sources (such as the tanker stacks). With high wind speed a plume will tend to flatten horizontally, disperse rapidly, and reach the ground quickly. With low wind speed, a plume will tend to rise higher, spread slowly, disperse less rapidly, and reach the ground slowly. Further, in a low level atmospheric temperature inversion when pollutants become trapped by a "lid" and there are low wind speeds, a plume tends to rise and become concentrated at the inversion level. Depending on the time and nature of the inversion break-up and the stability of the air under the inversion, the ground concentrations can become high or remain low.

SO_x Results--

Table 11 summarizes the air quality results for SO_x from various studies pertaining to the proposed Port of Long Beach/SOHIO project. Since the emissions are totally dependent on the assumed tanker scenarios and the assumed meteorological conditions are independent of the location (except for expected frequency), these results could apply to any proposed port location with similar terrain features. The presence of nearby hills or sloping terrain, if close to the port area, could alter the point and magnitude of maximum concentrations. All of the model results discussed in Table 11 assumed flat terrain features.

Of particular interest is the lack of agreement with respect to almost any of the parameters between the four reports. For the one-hour scenarios, the results ranged from "worst-case" incremental effects of 6 pphm (SOHIO) to 73 pphm (PES - Urban stability class A). Even comparing the four results for a common stability class, D, (using the PES-Urban model) the results range from 6 pphm to 62 pphm. Of course, much of the

cause for this range is due to the assumed "worst-case" scenario. If the scenarios are normalized to reflect .55% fuel, the results "agree" relatively well. They indicate a range of 5 pphm (BLM) to 15 pphm (PES) incremental increase in SO_x concentration when 3 large tankers simultaneously offload crude in port.

The assumed meteorological conditions also differed greatly between analyses which, as was previously discussed, affect the estimated pollutant dispersion and the point where the ground is touched. BLM chose high wind speed conditions causing a ground maximum concentration at 100 meters downwind. PLB, SOHIO, and PES assumed low wind speeds and inversion conditions. The PES Urban stability parameters account for increased dispersion in an urban environment which brought the maximum concentrations closer to the emission source. With the tankers emitting over water, stability classes A-C are less likely to occur until land is reached (16). The SOHIO analysis used actual worst day conditions recorded in Long Beach. The analysis indicated that the incremental addition would not cause standards to be exceeded (77).

All the reports used the same source for exit velocities and temperature for input to the effective heights calculation. However, as can be seen in Table 11, different formulae were used to calculate the effective height.

In summary the results of the one-hour "worst-case" air quality analysis indicate that while considerable disagreement exists as to a proper scenario, the three relatively independent studies indicate that a baseline "worst-case" of three 165K (or 120K) DWT tankers burning .55% fuel offloading simultaneously will cause a maximum 5-15 pphm incremental increase in SO_x air quality concentrations at some point downwind. A directly proportional incremental increase can be expected for tankers burning higher sulfur fuel and a directly proportional incremental decrease can be expected if fewer tankers are offloading during the one-hour period.

Since California* and Washington currently have one-hour air quality SO_2 standard, the incremental value of the "worst-case" would have to be added to the ambient (or "worst-case") air quality level at the location of maximum concentration in order to evaluate violations of the standard and the number of persons exposed. It should be noted that the SOHIO proposal would involve a berthing facility approximately 2 miles (3200 meters) from a residential area and any offshore buoy system would be even further offshore. Maximum ground level concentrations therefore may likely to occur over water or within a port facility.

For longer averaging times the wind and meteorological conditions can no longer be considered constant and further dispersion can be expected, thus lowering the magnitude of the maximum incremental contribution the tankers would contribute to the air quality level. The BLM report indicated a 33% decrease in maximum concentration for 3 hour averaging (to 20 pphm) and a 500% decrease (to 6 pphm) for 24 hour averaging. The PLB report indicated a 2200% decrease for 24 hour averaging (to .45 pphm). The SOHIO analysis indicated a 1-3 pphm incremental increase for 24-hour averaging. Since the BLM report assumes 35% sulfur content, the three reports together indicate a maximum incremental increase of .3-1 pphm in SO_2 air quality levels if 2-3 large tankers were offloading simultaneously over a 24 hour period and were each using .35% fuel.

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*The California one-hour standard is under litigation and is not currently in force.

None of the reports indicated the effect on yearly air quality averages. It would appear that the entire project would meet the EPA definition of a large point source and could have a noticeable effect on annual SO_2 air quality averages in the local area. Also the relationship between SO_2 emissions and the formation of sulfates were not evaluated in the reports.

NO_x Results--

Modeling the relationship between NO_x emissions and resultant air quality is difficult since NO, the usual combustion emission, reacts over time with other pollutants and oxygen to form NO_2 and other products. The speed of reaction is also dependent on atmospheric conditions and the relative ratios to other pollutants. Dispersion modeling was used by PLBM, PES, and SOHIO in evaluating the SOHIO project NO_x concentrations downwind for 1-hour averaging times. These results are directly proportional to the SO_x results since physically the same plume would contain both pollutants. Table 12 indicates that the "worst-case" situation would produce expected incremental concentrations ranging from 4 pphm to 22 pphm (excluding the A-C stability cases). There is relatively close agreement between the three studies if the emissions are normalized to the same value, and stability Class D is chosen in a "rural" setting.

There were no attempts to evaluate yearly incremental NO_x concentrations for analysis with respect to National NO_2 standards.

HC Results--

Table 13 summarizes the results from 3 studies of the SOHIO proposal using reactive models to simulate HC emissions from both tanker emissions and storage facilities. Because reactive models give results on an absolute basis rather than an incremental basis, each study ran scenarios to represent a baseline case (e.g., without a project), a storage facility only case, and a tanker scenario only to reflect incremental changes. The studies were performed for the proposed facility at the Port of Long Beach and might not be representative of alternative sites with lower background emissions. As is evident from Table 13, each study assumed different levels for the "worst-case" and thus has different absolute concentration results.

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
							[illegible]		[illegible]	[illegible]
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							[illegible]		[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

TABLE 13

SUMMARY OF OXIDANT AIR QUALITY MODELING RESULTS FOR THE PORT OF LONG BEACH

STUDY	SCENARIO	PROJECT HC EMISSIONS	MODEL	CALIBRATION DAY/PARAMETERS	PLACE/TIME OF START/ TIME OF MAXIMUM CONCENTRATION	MAXIMUM CONCENTRATION Or INCREASE
[illegible]	Total Emissions	[illegible]	[illegible]	July 25, 1973/Not Given	Pomona/9AM/3PM	.2 PPHM [illegible]
[illegible]	Baseline	0	[illegible]	Sept. 19, 1969/Not Given	Fullerton/9AM/12NOON(Storage) Huntington Beach/12NOON(Pier J)	- [illegible] - [illegible]
	Storage Only	[illegible]				.22 PPHM
	1-700 Ballasting	[illegible]				2.02 PPHM
	3-700 Ballasting	[illegible]				7.34 PPHM
[illegible]	Baseline	0	[illegible]	July 11, 1973/Wind:2-5M/SEC,	Pomona/9AM/2PM	- [illegible]
	Storage Only	[illegible]		Mixing: [illegible]		.2 PPHM
	[illegible], 1-700 Ballast	[illegible]				.3 PPHM
	[illegible] Pumping	[illegible]				.7 PPHM
	[illegible] Ballast/[illegible]	[illegible]				2.1 PPHM
	[illegible] Pumping	[illegible]				8 PPHM
[illegible]	22 Storage Tanks	[illegible]	[illegible]	Wind [illegible], STABILITY [illegible]	[illegible]	14 PPHM HC
		[illegible]	[illegible]	Wind [illegible], STABILITY [illegible]	[illegible]	17 PPHM HC

Sources: [illegible]

The "storage-only" scenarios represent an implied tradeoff since emissions were calculated for a new facility less the emissions for the current storage facilities that would be removed. Each of the studies indicated that an ozone increase of .1 to .2 pphm would result from the new facilities. When consideration is made for model inaccuracies and the possibility that the emissions from the new storage facilities may be overestimated, the results indicated little, if any, air quality impact from a new storage facility.

The tanker scenarios were very sensitive to assumed emissions. The PLB report did not evaluate tanker emissions since it was assumed only inerted tankers with segregated ballast would use the facility. There were definite differences indicated between the results given by the BLM reactive model and the PES reactive model. The worst-case BLM scenario involved three 70K dwt tankers taking on ballast simultaneously into empty crude oil storage tanks. The 6239 pound/hour HC emissions resulted in a 7.5 pphm increase in ozone concentrations. The "worst-case" PES scenario involved 3-165K tankers purging in port. The 25000 pound/hour HC emissions resulted in an 8.0 pphm increase in ozone concentrations. The large emissions difference between the two studies would not be expected to produce similar ozone concentration increases. It is suspected that the cause for this difference is related to model differences rather than assumed meteorological conditions. The models used by PLB and BLM are similar and their results were similar. (The PLB report had data to indicate that a scenario involving emissions on the order of 6239 lb/hr would create an 8 pphm incremental increase in ozone concentrations.) Therefore either the PES model results in estimates that are low or the PLB and BLM model estimates are high.

It is obvious that the range of results is very dependent on the HC emissions scenario that is the most realistic "worst-case" situation. Purging in port, if allowed, would represent a "worst HC" emissions scenario. However, the necessity to purge in port is not all clear, except in an emergency, if inerting systems are used and if tank-washing is performed at sea (16). The frequency with which an emergency situation will require in-port purging was not discussed by any of the reports. It appears likely that the "worst-case" HC emissions will involve instances where non-segregated ballast tankers will simultaneously take on ballast in port. The probability of this occurring was previously discussed in the discussion of emissions scenarios probabilities.

One final analysis was performed that relates HC emissions from a proposed storage tank farm at Port Angeles to incremental air quality concentrations (24). The results indicated that, under severe meteorological conditions and persistent wind speed, the HC 3 hour standard would be violated approximately 1.3 kilometers downwind. While the lack of HC measurements in the area and the reactivity of HC with other possible pollutants weaken validation of these results, the emissions levels are less than those predicted for the Long Beach facility. This could indicate 3-hour standards violations at Long Beach under similar conditions. None of the other studies evaluated the 3-hour HC standard.

Summary of Air Quality Analyses

It appears that the air quality impact due to the building of port facilities to handle large quantities of Alaskan oil can be minimized by placing constraints on the set of tankers that may use these facilities. Constraints on allowable tanker operations that could be performed individually and simultaneously while in port would further reduce emissions and air quality impacts. A current issue involves the legal mechanisms for implementing constraints and which agencies would be responsible for enforcement. The "worst case" conditions that have been presented for air quality analyses are associated with extremely low probabilities when consideration is given to the joint probability of the emissions scenario and meteorological conditions used in the analyses. Further work should be performed to evaluate the "worst" cases with probabilities that match the hourly and daily air quality standards (e.g. 1 in 365 days and 1 in 365x24 hours).

HC--

Tanker purging, ballasting, and venting and storage facilities are the three principal potential contributors to HC emission in port. By 1979 there will be enough tankers in the Alaskan trade with segregated ballast to eliminate this source of emissions (16). Even tankers with partially segregated ballast can leave port without displacing cargo hold vapors and can complete the ballasting operation at sea. It would seem feasible, and is currently proposed, that all Alaskan trade tankers using a facility be required to have sufficient segregated ballast to leave port without emitting ballast related HC (16,36,77).

Purging a cargo tank has the potential of producing severe air quality deterioration as demonstrated in the PES and ARB scenarios for 3-165K DWT tankers. It has been stated that the need to purge is associated mainly with tank cleaning and maintenance operation (16). Tank cleaning would normally be performed at sea or at a port facility that can handle the oily water. It would be advantageous to have a closed vapor recovery system at such a facility. It has been stated by SOHIO that no purging would occur at the Port of Long Beach by its inerted tankers (36).

A ban on this operation, as with ballasting, could become an administrative operating rule for any inerted tanker delivering Alaskan crude. One problem that may occur with such a rule is the mechanism of enforcement. Monitoring equipment and inspection would be required to regulate the rule.

Venting HC to the atmosphere occurs in non-inerted ships following unloading. From both a safety standpoint and an emission standpoint, inerting systems appear to be desirable. Many of the Alaskan trade tankers will be inerted. The cost and effort of converting non-inerted tankers has not been discussed by various reference reports. Therefore, the feasibility of requiring all Alaskan trade tankers calling at a port facility to be inerted is unknown.

The crude oil storage facility emissions had a moderate effect on resultant ozone concentrations when air quality models were used for the proposed Port of Long Beach facility (1 pphm increase without tradeoffs). Given the results from the CBI scale model testing the evaluation of true emission factors through further field study is desirable since a considerable overestimation of emissions may be involved. Further work in possible vapor recovery techniques with respect to these facilities is also desirable. Tradeoffs have been suggested for the Port of Long Beach such as removing older higher polluting storage facilities with equivalent emissions to the proposed facility (36).

In summary, hydrocarbon emissions can be controlled to a large extent through administrative control of tanker types and operations to be allowed in a port facility. Except for inerting tankers and designing vapor recovery systems for the large storage facilities, it appears that these measures can be accomplished with little impact on the proposed fleet in terms of time and cost. The impact on air quality, if these measures are taken, should be minimal.

SO_x --

The SO_x air quality analyses for "worst-case" short term emissions scenarios (e.g., 3 tankers simultaneously offloading for at least one hour) indicated maximum ground level incremental increases in ambient air quality concentrations that would be less than existing Washington and California standards. The maximum ground level values were found to occur relatively near tanker berths. The various models relative to the SOHIO project or proposed offshore unloading facilities did not take into account the effects of water/land meteorological conditions or topography and differed in results due to assumed meteorological conditions and fuel sulfur content. To minimize the probabilities of the "worst-case" occurring operational restrictions on simultaneous offloading might be imposed if (1) severe meteorological conditions are present and (2) high sulfur fuel is being used by 2 or more tankers simultaneously.

From an emissions growth viewpoint, the impact could be minimized by allowing only .5% fuel to be utilized by Alaskan trade tankers in port. Some of the proposed Alaskan fleet will have this capability through the use of separate fuel tanks. Further measures to offset emissions growth would require all tankers (including foreign flag tankers) calling at a facility to burn low sulfur fuel. Since the presence of separate fuel tanks for in-port use does not guarantee low sulfur fuel will be used, monitoring and inspection equipment would be required to insure compliance. There is also an implied reduction in sulfur emissions due to low-sulfur fuel used by Alaskan trade tankers replacing foreign tankers delivering equivalent foreign crude. This "tradeoff" will be dependent on the market and traffic at the chosen alternative location.

NO_x --

The NO_x air quality results were very sensitive to the emission factors used in the various studies. The PES "worst-case" analysis indicated that California 1-hour standards violations could occur due to the project alone. The Port of Long Beach report, for the same emissions scenario showed a maximum concentration that was 30% of the standard. The number of NO_x violations in the PLB area and South Coast air basin, in general, indicate that NO_x air quality may deteriorate in the local area. Since NO_x is also a precursor for oxidant production, it would seem that, from an air quality viewpoint, NO_x may be the most important pollutant to examine by further field measurements.

The emissions scenarios used in the NO_x "worst-case" involve the offloading of crude by 3 165C dwt tankers. Administrative controls similar to those suggested for SO_x could be imposed to prohibit this situation or similar ones. This would reduce the probability of one-hour NO_2 standards violation. However, this control could seriously delay throughput since there is a relatively high probability that 3 berths will simultaneously have tankers pumping. It may be necessary to control simultaneous pumping operations only on meteorologically poor days.

Emissions tradeoffs involving NO_x are difficult to identify. Inerting will reduce NO_x emissions by approximately 15% but does not appear feasible in smaller tankers. A SOHIO analysis indicates that the substitution of Alaskan trade vessels for foreign crude carrying vessels at the Port of Long Beach will result in SO_x emissions reductions but also will result in NO_x emissions growth over time (48). Since nationwide NO_x emissions are forecast to become a major problem in the 1980-2000 period, the lack of controls and/or tradeoff opportunities appear to be a serious problem. As a long term solution, results of current EPA research in nitrogen removal from fuel and improved combustion techniques may allow for reduction in these emissions. Short-term tradeoffs have been proposed by SOHIO such as installing NO_x emission reducing equipment on stationary internal combustion engine sources in the LA area (77).

WATER QUALITY

Many sources of pollutants may impair water quality as a result of the construction and operation of pipelines, marine terminals, and associated tanker movements. Such sources include downstream sedimentation from construction at stream crossings, oil spills from pipeline breakage or leakage, the discharge of water used for hydrostatic testing, the flushing of ballast tanks, discharges of bilge water and sewage, and turbidity during dredging of harbor sediments. Many of these sources can be easily abated or controlled. The oil from the North Slope, however, will be carried by a fleet of U.S. tankers from the Port of Valdez to potential distribution points on the West and Gulf Coasts. This large amount of oil being moved by a number of tankers has focused public attention on the likelihood of the occurrence of massive spills which pose a threat to the coast ecosystem and public safety. Such public attention has been heightened by a series of tanker catastrophes near coastal U.S. waters during the months of December, 1976 through January, 1977 (56, 57, 58). Many of these incidents involve human error or faulty equipment. Should a large oil spill occur in the open ocean, especially under turbulent conditions, such common containment and clean up equipment or agents as booms, absorbent materials, surface collecting agents, and skimmers may not be highly effective, although weathering and dispersal in the open ocean would attenuate coastline impacts. Current emphasis is on oil spill prevention as a measure to minimize the occurrence of oil spills.

Tanker Status

All of the tankers which will transport North Slope crude to U.S. ports will be subject to the regulations of the Merchant Marine Act of June 5, 1920 (46 U.S.C.A. Section 883), commonly known as the Jones Act. The Act requires that such coastal movement between domestic ports be carried out by U.S. built and owned tankers operated under the U. S. flag by U. S. masters and crews. U. S. tankers currently operating in foreign trade are capable of meeting Jones Act requirements and may enter the domestic coastal trade if construction subsidies are repaid or if operational subsidies are suspended. Such vessels are subject to regulations for tank vessels engaged in the carriage of oil in domestic trade which were promulgated by the U.S. Coast Guard as one step in the implementation of the Ports and Waterways Safety Act of 1972 (PL 92-340). These requirements for vessels larger than 70,000 dwt include distributed segregated ballast, two slop tanks (for retention of tank washings, oil residues, and dirty ballast residues) and an oily residue tank for the containment of oil leakages and sludge (32). The Coast Guard currently is extending these standards to U. S. vessels in foreign trade as well as foreign vessels entering U. S. waters. These measures are intended to substantially reduce the amount of oil released to the ocean by U.S. seagoing tank vessels as well as foreign tankers in U. S. waters. Since these requirements apply to Jones Act tankers and therefore to tankers carrying North Slope crude to U. S. ports, the entire fleet of tankers carrying North Slope oil is expected to possess fully segregated ballast by 1980 (16). Also by 1980 approximately 30 percent are expected to have collision avoidance radar systems and about 33 percent to have double bottoms or hulls, segregated tanks for the carrying of low sulfur fuel, and inert gas systems.

Oil Spill Analysis

Several extensive studies have been performed to evaluate the probability of oil spills and assess the potential environmental damage associated with the transportation of Alaskan crude. FEA (16) has presented hitherto unpublished statistical results based on analysis of 1973-1975 data from the Coast Guard Polluting Incident Reporting System (PIRS). The data base, while not restricted to Alaska information, gives a good indication of historic risk patterning between alternative west coast port facilities. Based on the data analyses, quantitative rankings of spill risks of each alternative port are given. Summary information is also given pertaining to the environmental setting at the port alternatives. A comparative qualitative ranking of site by various environmental criteria is presented.

The BLM Environmental Impact Statement for the proposed Port of Long Beach/SOHIO pipeline project contains the results of spill risk analyses as well as an extensive discussion of spill trajectories. These studies used historic data to compute probabilities of spills and their expected volume due to terminal interface operations and vessel accidents. In addition, SAI (39) computed separately the probability of total loss of cargo and its associated volume over the life of the project and for each year. The following sections summarize the results from each of these studies.

FEA Risk Analysis--

Since the data base used to derive relative risk rankings contains the most up-to-date statistics on west coast oil spills, background statistics were provided on the oil pollution problem in general and the subset associated with tankers. Some of the findings were:

a. There is a high variability in spill volumes from year to year with catastrophic spills distorting badly most gross volume statistics. Tankers, which produced only 20% of the known spill incidents contributed 34% of the volume spilled. Marine terminal spills, on the other hand contributed 9% of all known spills but only 1% of the volume.

b. Approximately 62% of all known oil spill incidents involved personnel errors with vessel collisions and groundings accounting for 2%. From a volume standpoint, however, personnel errors accounted for 5% and grounding and collisions 33% of the pollutants (Equipment failure accounted for another 33% of volume and 25% of the known incidents). When examined across alternative regional port locations, a consistent 70% of the known incidents were due to personnel error. Even when only tanker spills were considered the personnel errors were responsible for 60% of the known incidents;

c. Only 12% of vessel and terminal spill incidents occurred in areas outside of the port activity;

d. Tanker collisions with vessels account for only 15% of tanker casualties with groundings and collisions with fixed or submerged objects accounting equally for the remainder;

e. Tanker spill incidents are highly correlated with tanker traffic and crude volume transferred at terminals;

f. Tanker age does not appear to correlated with polluting incidents; and

g. There does not appear to be a relationship between tanker size and frequency of spill incidents.

Based upon some of the above information and risk criteria, a relative risk table was formed for candidate locations. An excerpt of that table is presented in Table 14 for the current set of ports that will receive Alaskan oil, or are prime candidates to become major Alaskan oil terminals. The analysis indicates that Offshore Estero Bay and Avila Beach have the lowest risk characteristics and the San Francisco port the highest risk characteristics (Port Angeles and Kitimat were not ranked in the table).

If only the highest correlative criterion is used, that is per tanker arrivals and throughput, then the rankings would appear as in Table 15. Port Angeles was included in these rankings and is considered a "low" relative risk location. Since many spills are associated with the tanker terminal interface, the results indicate that in-port terminals are, in general, higher risk locations. It should be noted that these rankings are based on spill frequency results only and do not reflect spill volumes. Since spill size does not appear to be related to geographic location, it need not be weighted into the rankings.

The statistics used for the "off-shore" configurations have been questioned by the Port of Long Beach (78). The facilities necessary for large tankers to offload offshore would involve two or three single point mooring (SPM) buoys anchored 3 to 5 miles offshore. At these moorings the tankers must have space to be able to revolve a full 360° about the mooring and have adequate maneuvering room to approach the buoy from any direction with adequate bottom clearance. These requirements would tend to place the buoys in relatively open ocean areas. The statistics develped for the "offshore" configuration by FEA came from facility configurations that are more protected from the open ocean and use fixed mooring for offloading. The relative difference in risk rates between these two configurations (if any) is not reflected in the statistics. Further analyses are now being conducted relative to the problem.

Given the above results, projections were made of the expected number of spills at the various alternative port sites as a function of projected throughput volume and assumed fleet mixes. Using spill size distributions derived from the data base, Table 16 was then produced. The affect of low volume in-port oil spills and their relationship to the number of arrivals becomes obvious in this Table when the San Francisco alternatives with and without dredging are compared.

Finally, Table 17 was developed to reflect the capability of containment. These results were based on relative rankings of criteria such as visibility, high winds, calm seas, currents, high seas, etc. Given there is a spill, using these criteria the relative protected ports of Los Angeles and Long Beach have the highest probability of containment. The San Francisco and Puget Sound harbor ports have both high spill risks and poor containment probabilities. If spill risk and containment alone were the criteria for choosing a port, the analysis would favor Offshore Estero Bay and Avila Beach, with the Southern California ports and Port Angeles ranked next.

There is, in addition to the spill risk analysis, a substantial amount of information on potential environmental impacts that may occur at

TABLE 14

RELATIVE SPILL RISK
As Suggested By Some Indicators
(1 = Higest Risk, 10 = 10 times lower risk.)

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Anacortes	5	4	3	3	2	2	2	1
Ferndale	3	2	2	10	10	10	5	7
Long Beach Harbor	6	3	6	6	3	6	6	6
Los Angeles Harbor	3	3	2	7	7	7	3	3
Offshore Avila Beach	7	10	8	10	10	10	7	10
Offshore Estero Bay	7	10	8	10	10	10	7	10
Richmond (San Francisco)	3	5	2	2	2	2	3	6
Treasure Island (San Francisco)	3	1	2	2	2	2	2	1

Source: FEA (16)

Table 15

UNWEIGHTED OIL SPILL RISK RANKINGS
(In alphabetical order by group)

Feasible terminals with the lowest relative frequency of tanker spills and casualties per tanker arrivals and oil throughput volumes: (9.0-10.0)

- Offshore Avila Beach
- Offshore Estero Bay
- Port Angeles

Feasible terminals with relatively moderate tanker spill and casualty frequencies per tanker arrivals and oil throughput volumes: (3.5-6.5)

- Ferndale (Puget Sound)
- Long Beach Harbor
- Los Angeles Harbor

Feasible terminals with a greater relative frequency of tanker spills and casualities per tanker arrivals and oil throughput volumes: (2.0-3.5)

- Anacortes (Puget Sound)
- Richmond (San Francisco)
- Treasure Island (San Francisco)

The following terminal sites received no tanker arrivals or oil deliveries during 1973-1975 or insufficient data exists to allow for their evaluation:

- Kitimat

Source: FEA (13)

TABLE 16

ANNUAL TANKER AND TERMINAL SPILLS BY REGION AND SPILL SIZE (gallons), 500,000 bpd ADJUSTED FOR REGIONAL SPILL RATE DIFFERENCES

	0-100	100-1000	1000-10,000	10,000-100,000	100,000
British Columbia Fjord Sites (Kitimat)	5.85	0.60	0.25	0.15	0.05
Northwest Ports (North Puget Sound)	6.90	0.75	0.30	0.15	0.05
Northwest Ports Small Tanker Scenario	9.70	1.00	0.45	0.20	0.05
San Francisco Bay Without Major Dredging	14.50	1.55	0.70	0.35	0.10
San Francisco Bay, With Major Dredging To Treasure Island	8.90	0.95	0.40	0.20	0.05
Central California Offshore	2.20	0.25	0.10	0.05	0.01
Southern California In-Port	6.30	0.65	0.30	0.15	0.05

Source: FEA (16)

TABLE 17

UNWEIGHTED SPILL CONTAINMENT RANKINGS
(In Alphabetical Order, by Group)

Feasible terminals with the greatest frequency of conditions allowing effective spill containment in the vicinity of their berths or buoys:

- Long Beach Harbor
- Los Angeles Harbor

Feasible terminals with relatively moderate frequencies of conditions allowing effective spill containment in the vicinity of their berths or buoys:

- Offshore Avila Beach
- Offshore Estero Bay

Feasible terminals with relatively low frequencies of conditions allowing effective spill containment in the vincinity of their berths or buoys:

- Anacortes (Puget Sound)
- Ferndale (Puget Sound)
- Kitimat
- Port Angeles
- Richmond (San Francisco)
- Treasure Island (San Francisco)

Source: FEA (16)

alternative port sites due to oil spills. The analysis defines two zones of impact. The first is a construction and operations zone which encompasses the area surrounding the terminal that would be potentially impacted. Second, since most spills occur within, or at the entrance to harbors, a loci of spill points were defined that followed tanker routes within one mile of an in-port terminal, one mile around each offshore mooring buoy, and along all pipelines from the offshore buoys and in-port berthing facilities. Using ocean current data, wind patterns, and in the case of Puget Sound and San Francisco tidal currents, oil spill impact zones were created that estimated the area covered after a three day period. Figures 14 through 17 are illustrative of the resulting area covered. These results, when taken with the spill risk and containment analyses, again show offshore Estero Bay and offshore Avila Beach as being the "safest" alternative. The Port Angeles area, although relatively open to the Juan de Fuca Strait, has a relatively small oil impact zone. All the other locations have the potential of exposing large areas to spilled oil.It should be noted that in protected harbors such as the Port of Long Beach, the spill area exposed would be very much smaller if the spill occurred within the port area.

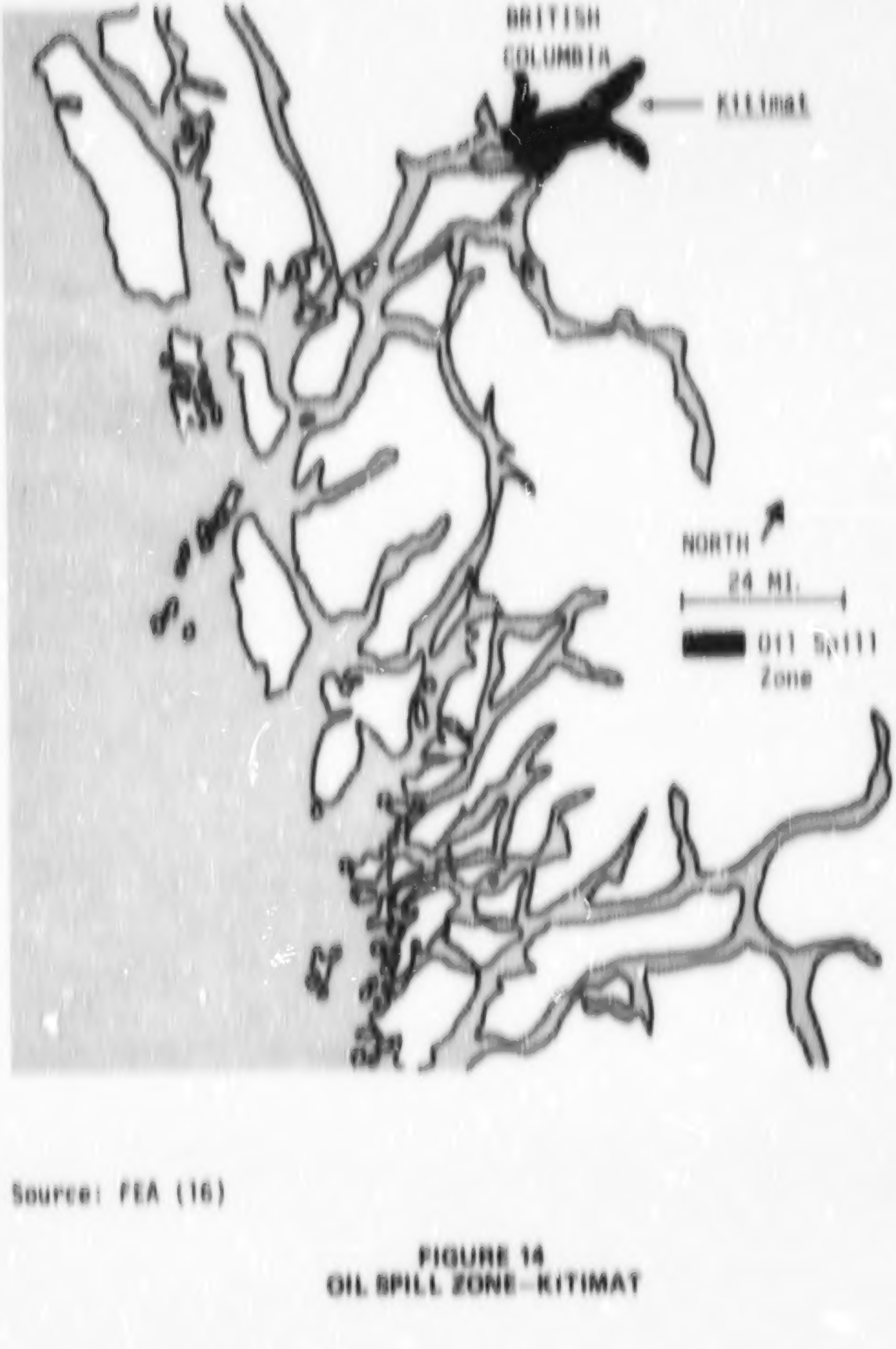
One final analysis was performed to assess the relative environmental importance of various criteria at each alternative location. The results of this analysis are shown in Table 18. The Estero Bay alternative would involve placing highly sensitive Morro Bay estuary in risk. The Avila Beach alternative although near Estero Bay, would tend to lessen the risk to the estuary. State Water Resources Board and the California Department of Fish and Game have indicated that the Avila Beach alternative may be more sensitive to an oil spill than indicated by Table 18 (79). Locations further south in San Luis Obispo Bay such as Guadalupe Dunes have been recently discussed as being a less sensitive location.

When these results are compared with the risk analysis, containment analysis, and impact zone analysis, the following general conclusions can be drawn:

1. Given that the risk assessment is correct, Offshore Estero Bay is attractive from all but an environmental/ecological importance viewpoint.

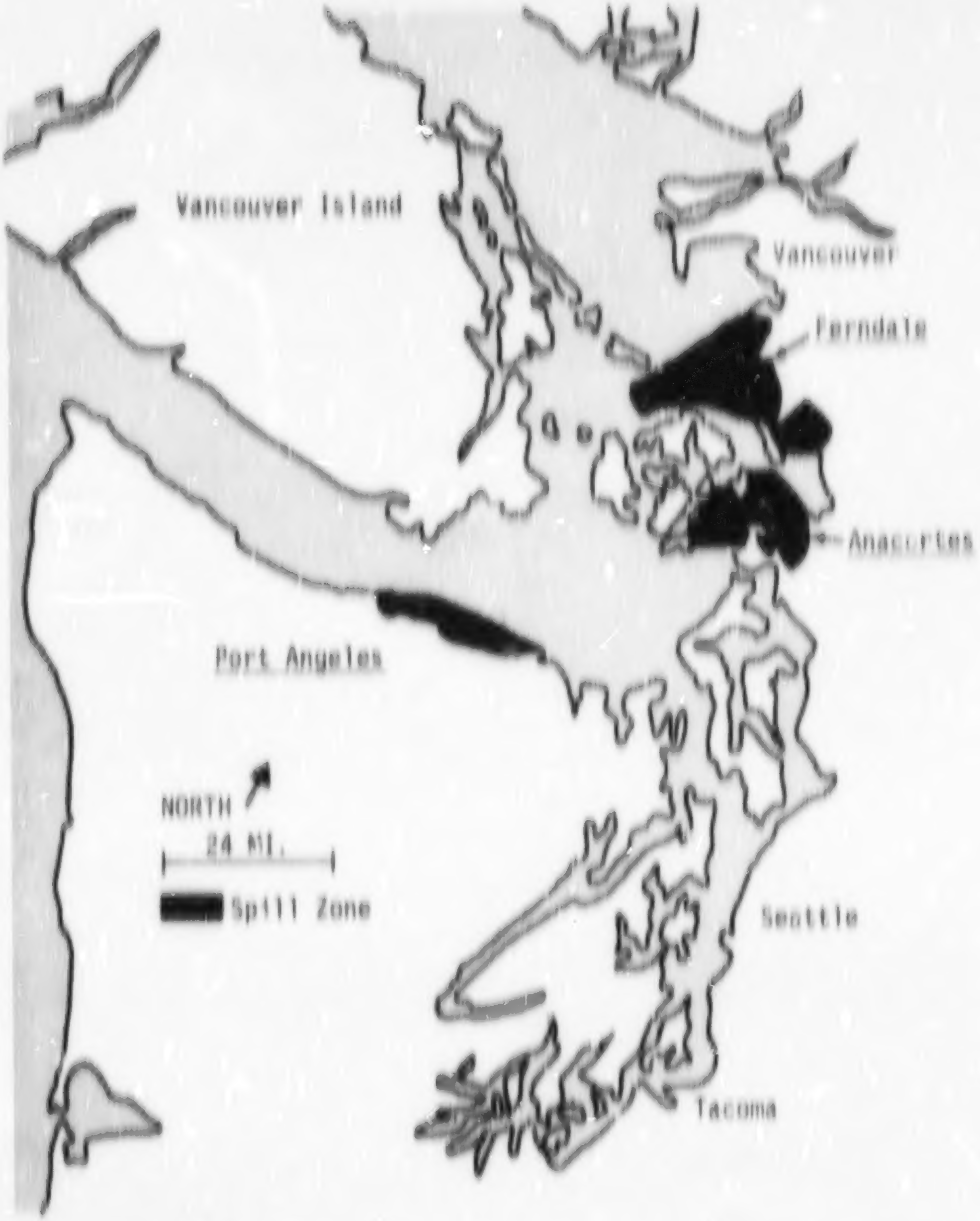
2. Port Angeles, except for poor relative containment probabilities is attractive as a site. However, the relatively low spill risk ranking for this alternative may be due to chance since relatively small amount of traffic is handled there.

3. The Southern California ports (Long Beach and Los Angeles) rank next with the big positive being excellent containment probabilities. One aspect of the risk analysis not discussed by FEA or BLM with respect to accident risks at these ports involves the possibility of increased navigational hazards due to the presence of exploratory and production offshore oil well rigs in Santa Barbara Channel. The affect of traffic to and from the rigs as well as the platforms themselves has not been discussed with relationship to the relatively large tankers that will be using the sea route in the Channel.


BRITISH
COLUMBIA
Kitimat
NORTH
24 MI.
Oil Spill
Zone

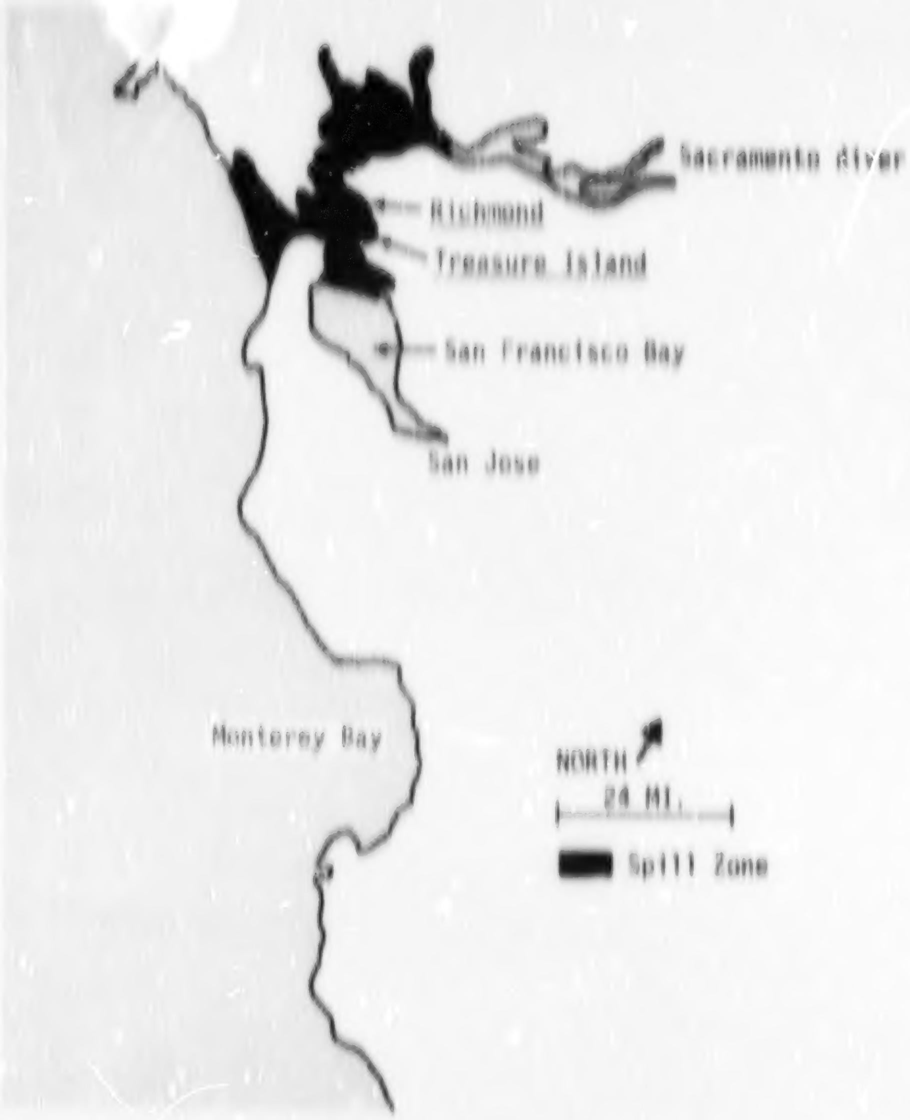
Source: FEA (16)

FIGURE 14
OIL SPILL ZONE–KITIMAT


Vancouver Island
Vancouver
Ferndale
Anacortes
Port Angeles
NORTH
24 MI.
Spill Zone
Seattle
Tacoma

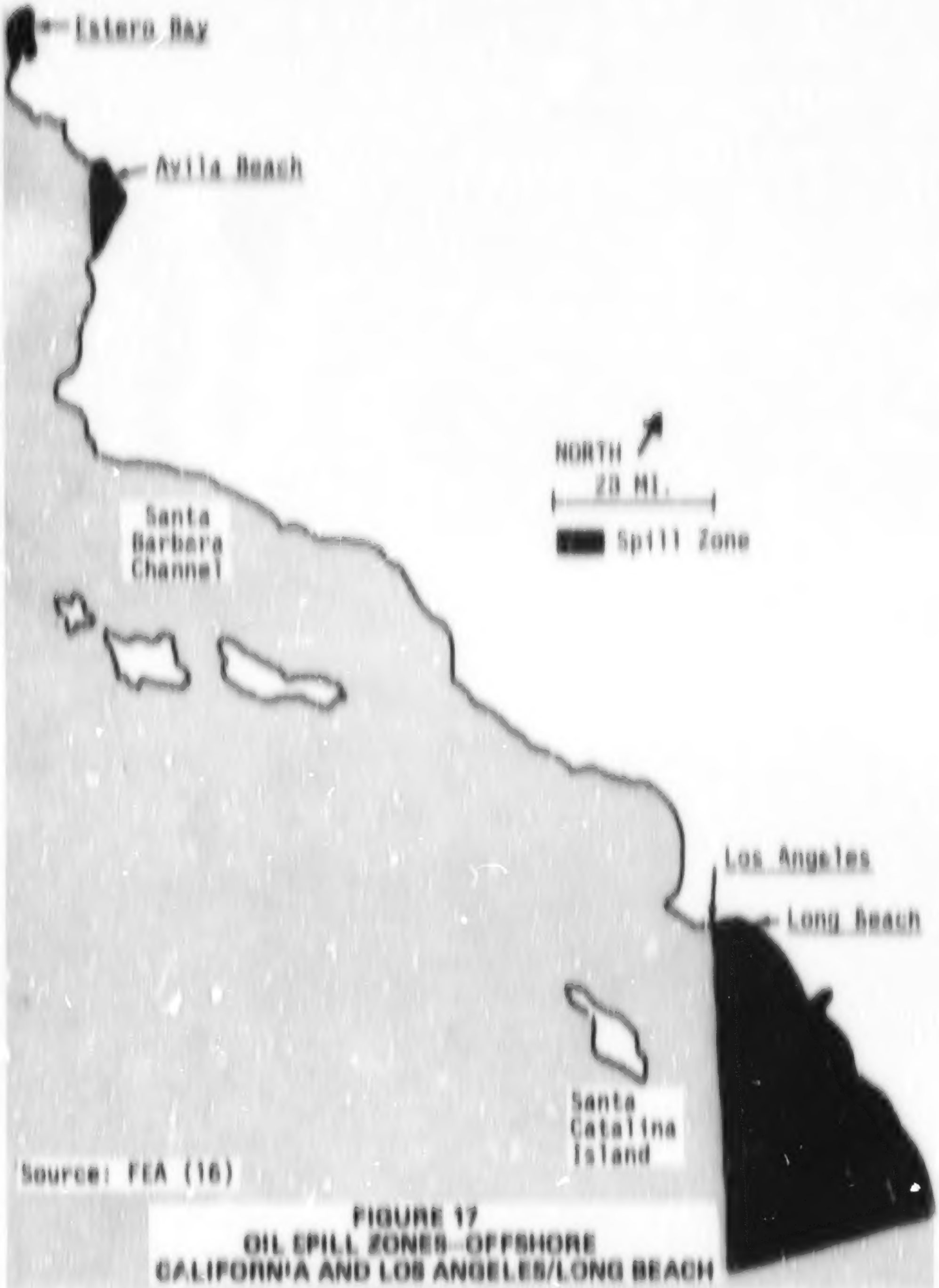
Source: FEA (16)

FIGURE 15
OIL SPILL ZONES—NORTHWEST


Sacramento River
Richmond
Treasure Island
San Francisco Bay
San Jose
Monterey Bay
NORTH
24 MI.
Spill Zone

Source: FEA (16)

FIGURE 16
OIL SPILL ZONES-SAN FRANCISCO


Estero Bay
Avila Beach
NORTH
20 MI.
■ Spill Zone
Santa Barbara Channel
Los Angeles
Long Beach
Santa Catalina Island

Source: FEA (16)

FIGURE 17
OIL SPILL ZONES--OFFSHORE
CALIFORNIA AND LOS ANGELES/LONG BEACH

TABLE 18

ENVIRONMENTAL AND
ECOLOGICAL RELATIVE RANKINGS

Potential Effects On:	Commercial Fishing and Aquaculture	Finfish Mollusks, and Crustaceans	Rocky Intertidal Zone Communities	Kelpbed Ecosystems	Marine Mammals	Rare, Threatened, or Endangered Animals	Recreational Activities (non-fish)	Reserves, Refuges and Similar Areas	Seabirds and Waterfowl	Sport Fishing Activities	Wetlands, Estuaries, Shallow Bays, Marshes Lagoons, Eelgrass Beds and Other Productive Area
Kitimat	1.2	2.5	5	1.2	3	1	1.2	1.2	2.5	1.7	3.7
Ferndale (Cherry Point)	2.5	5	2.5	1.2	2	1	3.7	5	1	2.5	5
Anacortes (March Point)	3.7	3.7	2.5	3.7	4	1	3.7	5	5	3.7	3.7
Port Angeles	2.5	1.2	3.7	3.7	1	1	3.7	3.7	5	2.5	1.2
Treasure Island (San Francisco)	2.5	5	5	1.2	3	5	3.7	2.5	5	3.7	5
Richmond (San Francisco)	2.5	5	5	1.2	3	5	2.5	2.5	5	3.7	5
Offshore in Estero Bay	3.7	5	2.5	1.2	5	5	5	5	3.7	3.7	5
Offshore Avila Beach	2.5	1.2	2.5	1.2	3	1	1.2	2.5	2.5	2.5	2.5
Los Angeles Harbor	5.0	2.5	3.7	2.9	2	5	5.0	5.0	3.7	5.0	3.7
Long Beach Harbor	5.0	2.5	3.7	2.5	2	5	5.0	5.0	3.7	5.0	3.7

UNWEIGHTED COMMERCIAL-RECREATIONAL RANKINGS

Range of "Lowest" Group:	1.2-2.5
Range of "Relatively Low" Group:	2.9
Range of "Moderate" Group:	3.3-3.7
Range of "Greater Relative" Group:	4.1-5.0

UNWEIGHTED ECOLOGICAL RANKINGS

Range of "Lowest" Group:	1.7-2.0
Range of "Relatively Low" Group:	2.5-3.2
Range of "Moderate" Group:	3.4-3.6
Range of "Greater Relative" Group:	3.8-4.4

Source: FEA (16)

6. Offshore Avila Beach, or more likely a point at the southern end of San Luis Obispo Bay, except for the moderate spill containment probability, ranks as the most desirable location using the above analysis criteria. The feasibility of this location with respect to the ultimate distribution of the crude and the economics of development of the location as a major port for Alaskan crude are not included in this conclusion. An additional factor that is not included in this assessment is the relative secondary impact the development of a major marine terminal might have on the various areas. It would appear that the long term secondary environmental and socio-economic impacts on the already developed port areas in Puget Sound and Long Beach would be far less than in the more undeveloped locations.

These values are subjective, but, when viewed across criteria for a particular location, give a definitive view of the type of oil pollution issues a proposed location would encounter.

BLM Risk Analysis--

The BLM discussion of oil spill probabilities references work performed for the Port of Long Beach (36) and an ERT study (59). The two studies used different techniques for assessing spill risks but ended up with similar estimates of probable losses. The approach to the analysis used was one of first assessing probable accident rates and then relating these to spill probabilities and size.

Accident rates compiled from various sources reveal that the Port of Long Beach has a relatively low tanker accident rate (1.9-2.4 per 1000 trips). This is at least partially attributed to the vessel traffic system (VTS) in place there (a similar system is under construction in Prince William Sound and Valdez). Tables 19 and 20 indicate the expected accident frequency by type and location for the assumed tanker fleet. The relatively high accident rate in San Francisco is attributable to higher traffic rates of small tankers due to harbor depth limitations.

Tables 21 and 22 were then used to generate spill probabilities and volumes. The ERT report examined the affects of a catastropic loss and found a .56 probability of a loss during the 25 year project life. Included in their analysis were factors for tanker age, inerting systems, a VTS, ballast tank placement, and double hull construction where applicable. Tables 23 and 24 were then computed to indicate the impact a catastropic loss would have on average spill volumes.

The volume of spills on San Pedro Bay with less than a major loss, as indicated in Table 24 (130 barrels), can be compared with the FEA results in Table 16. Assuming the one-third value for each interval and excluding the 100,000 or greater interval, the results of multiplying Long Beach spill rates yield a total of 153 barrels/year. The ten year estimate by PLB was 1726 barrels or 172.6 barrels/year. Given the relative independence of technique and data sources between the three analyses, the results are remarkably similar and lend credence to each analysis.

TABLE 19

PROJECTED SOHIO TANKER ACCIDENTS

IN A 10-YEAR PERIOD (LOCATION)

ACCIDENT CAUSE	Prince William Sound (Valdez)	At Sea	Santa Barbara Channel	San Pedro Bay (Long Beach)
	MMbbl/d[a] 0.7	MMbbl/d 0.7	MMbbl/d 0.7	MMbbl/d 0.7
Collisions, rammings, groundings	9.4	0.3	2.5	3.1
Structural failures	0.1	3.3	0.1	0.0
Fires, explosions, breakdowns	1.1	2.4	0.6	0.4
Total	10.6	6.0	3.2	3.5

Source: BLM (25)

[a] Million barrels per day throughput.

TABLE 20

PROJECTED SOHIO TANKER ACCIDENTS OVER 10 YEARS VALDEZ TO PUGET SOUND AND SAN FRANCISCO[a]

ACCIDENT TYPE	Valdez	At Sea	Coastal Waters	Puget Sound	San Francisco Bay
Collision, ramming, grounding	18.9	0.4	3.87	1.5	16.8
Structural failure	0.1	4.9	0.1	0.0	0.1
Fire, explosion, breakdown	1.1	3.7	0.9	0.1	1.0
Total	20.1	9.0	4.87	1.6	17.9

Source: BLM (20)

[a] Assuming 100,000 bbl/d to Puget Sound, 325,000 bbl/d to San Francisco.

TABLE 21

ACCIDENT LOCATION AND OIL SPILLAGE

ACCIDENT LOCATION	Percent of Accidents Involving Spills	Percent of Total Oil Spillage
At sea	19.5	55.7
Coastal	22.6	14.1
Entrance	22.2	19.3
Harbor	16.9	5.3
Pier	16.2	4.5

Source: BLM (20)

TABLE 22

SOURCES OF OIL POLLUTION FROM TANKERS

CAUSE	Annual Outflow[a]	Percent
Tank cleaning	967,000	69.7
Discharges[b]	100,000	7.2
Terminal operations	70,000	5.0
Casualties	250,000	18.0
Total	1,387,063	100.0

Source: BLM (20)

[a] Metric tons.

[b] Includes bilge pumping, leaks and bunkering spills.

TABLE 23

PROBABILITY PER YEAR OF SPILLS WITH LESS THAN TOTAL VESSEL LOSS WITH AVERAGE SPILL VOLUMES IN BARRELS

SPILL LOCATION	Probability	Volume
Prince William Sound (Valdez)	0.11	389
Prince William Sound to San Francisco	0.13	439
San Francisco to San Pedro Bay	0.077	302
San Pedro Bay (Long Beach)	0.037	130
Total	0.35	1,260

Source: ERT (55)

TABLE 24

PROBABILITY PER YEAR OF SPILLS WITH TOTAL VESSEL LOSS

AVERAGE SPILL VOLUME IN BARRELS

SPILL LOCATION	Probability	Volume
Prince William Sound (Valdez)	0.12	6,730
Prince William Sound to San Francisco	0.14	7,333
San Francisco to San Pedro Bay	0.086	3,883
San Pedro Bay (Long Beach)	0.040	2,243
Total	0.39	20,189

Source: ERT (59)

Pipeline Spills

Information on the projected number and size of pipeline oil spills was provided in the BLM report. An average loss of 1.33 barrels per mile of line per year occurred during 1974 for the transportation of 9 billion barrels of products. Based on throughput and length the SOHIO pipeline would expect a loss of 1400-1600 barrels/year. Based upon these values and an assumed distribution of spill types, Table 25 was compiled to indicate the expected volume of oil that will be spilled.

Certain locations (such as river crossings) will be especially sensitive to a major rupture in the pipeline. Based upon computations of the total volume between the closest valve on either side of the location and with allowance for automatic cutoff delay times, the maximum oil spill volume was calculated and is given in Table 26.

TABLE 25

APPROXIMATE PREDICTED PIPELINE STATISTICS (OVER-10-YEAR PERIOD)

EVENT	Number of Spills	Size of Spill (bbl)	Total Volume of Oil Spilled	
			Percent	bbl
Leaks below detection system threshold	400 (max)	indefinite	25	9,000 (max)
Leaks above detection system threshold	4 to 20	500 to 1,000	50	7,000 to 20,000
Ruptures	1 (max)	3,000 plus	25	9,000 (max)

Source: BLM (20)

TABLE 26

POTENTIAL MAXIMUM OIL SPILLS AT SENSITIVE LOCATIONS

LOCATION	Volume (bbl)
Santa Ana River	9,930
Whitewater River	13,428
Colorado River	5,417
Gila River	139
San Pedro River	4,260
Rio Grande	1,805
Pecos River	8,103
San Andreas Fault system	9,261

Source: BLM (20)

SECTION 6

PRESSING PROBLEMS

NATIONAL CONCERN

An urgent national concern affecting Alaskan oil was expressed in the Trans-Alaska Pipeline Act of 1973. The Act stated that

> "The early development and delivery of oil and gas from Alaska's North Slope to domestic markets is in the national interest because of growing domestic shortages and increasing dependence upon insecure foreign sources".

Today, the need to find solutions to the various problems of importing Alaskan oil still exists. Although it demonstrated that the U.S. is vulnerable to severe supply disruptions and oil price increases, the 1973/1974 oil embargo did little to curb U.S. dependence on foreign oil. Imports accounted for 23 percent of U.S. total oil consumption in 1970. Declining domestic production and rising demand has led to a rapid growth in imports which now amount to more than 40 percent of U.S. crude oil supplies (7). Thus, the need for a decrease in dependence upon foreign sources, a more favorable balance of payments situation, and a need for a secure supply of crude oil has caused considerable concern and determination by Federal and State officials as well as the private sector to seek new sources of crude oil and to develop efficient transportation systems for the huge untapped reserves of the North Slope.

The search for a system to carry the North Slope crude to market has been in effect since an Alaskan pipeline was first proposed in 1969 (6). By 1972 the following alternatives were being evaluated (60):

1. New pipelines from the U.S. West Coast to markets east of the Rockies.
2. Selling Alaskan oil to Japan in return for increased imports on the East Coast of the United States.
3. A new pipeline in Central America for transporting Alaskan oil to East Coast markets.
4. Transporting the oil through the Panama Canal to Gulf Coast ports.
5. Shipping oil around Cape Horn to East Coast markets.

Today these and other routes such as those of the Trans-Mountain and Trans-Provincial pipelines, which generally follow the original route of the Trans-

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Canadian Pipeline (an overland alternative to the Trans-Alaska Pipeline), are envisioned to serve not only eastern U.S. markets, but also to provide a source of crude to the Northern Tier States.

Such solutions, in the form of proposed transportation routes, must relate to one or both of these problems:

- To dissipate the expected West Coast crude excess - hopefully by movement to demand areas east of the Rocky Mountains.
- To supply the Northern Tier States which confront a decline in oil exports from Canada.

In the face of these problems, the Federal Government must respond in a manner consistent with the Trans-Alaska Pipeline Act to assure equitable allocation of North Slope crude oil (12):

> Section 410. The Congress declares that the crude oil on the North Slope of Alaska is an important part of the Nation's oil resources, and that the benefits of such crude oil should be equitably shared, directly or indirectly, by all regions of the country. The President shall use any authority he may have to insure an equitable allocation of available North Slope and other crude oil resources and petroleum products among all regions and all of the several States.

A question, often voiced at public meetings held for the purpose of discussing North Slope crude transportation alternatives is "Who decides?" (61). It is likely that decisions will be made by all levels of government and by agencies representing a wide variety of interests. Many decisions will be made in response to applications by a proposal sponsor for a permit to conduct a specific activity relevant to the proposal venture. Usually these applications are accompanied by detailed engineering plans which, together with the application, are available for public scrutiny during a period set aside for public comment or at public hearings. Examples of such permits are the following:

AGENCY	PROPOSED ACTIVITY	PERMIT
Corps of Engineers	Dredging of a port; Construction of breakwater; Pipeline across large river.	Permit for work in navigable waters.
Environmental Protection Agency	Installation of new stationary source of air pollutants.	Permit to construct.
Department of the Interior	Construction of pipeline across Federal lands.	Granting of rights-of-way.
U.S. Coast Guard	Operation of marine facility.	Approval of operation.

Generally, large scale cross country pipeline projects, especially if they cross a number of Federal lands requiring the granting of rights-of-way by the Department of the Interior, constitute "a major Federal action significantly affecting the quality of human environment" and come under the provisions of the National Environmental Policy Act of 1969 (PL91-190). Such an action requires the preparation of a Federal Environmental Impact Statement (EIS). The purpose of the EIS report is to document all environmental effects of the proposed actions and their alternatives for public understanding and to list measures to avoid or minimize effects of proposed actions and to restore or enhance environmental quality as much as possible. As early in the decision making process as possible, and in all cases prior to agency decision, a draft statement is prepared for review by appropriate Federal, State and local environmental agencies as well as the public. After comment, the statement is prepared in final form, incorporating all comments and objections received on the draft and indicating how significant issues raised during the commenting process (includes public hearings) have been resolved. Both the draft and final statement are filed with the Council on Environmental Quality and made available to the public (62). This EIS statement process is used successfully by Federal agencies to improve decisions affecting the environment and provides a useful tool to incorporate public opinion, as well as that of diverse agencies, into the decision making process (63). Currently this process is being applied to the movement of North Slope crude. A draft environmental impact statement has been prepared by the Bureau of Land Management (Department of the Interior) for the SOHIO proposal. A draft environmental impact statement may be prepared by the Department of the Interior for the Northern Tier Pipeline proposal.

The responses by appropriate governmental units with respect to North Slope crude will require a concerted effort to establish and maintain a high level of communication and coordination. Varying parts of the U.S. will have varying needs for energy and environmental protection. Approved transportation systems will need to be flexible to provide for changes in future energy patterns. In the development and finalization of these projects the environmental impact statement process will aid in alerting agency decision makers, the public, and ultimately Congress and the President to the environmental risks involved and allow for a responsive approach toward the establishment of environmental compatibility.

FUTURE CRUDE SUPPLIES - NEW PROBLEMS

In the future, changes in the sources of crude supplies on the West Coast are inevitable. Foreign high sulfur crude will be replaced by heavy, high sulfur crude from the North Slope (Figure 18). Should an optimistic rate of North Alaskan crude production be realized, as proposed by the Federal Energy Administration (Figure 19), the West Coast may be subjected to a substantially greater excess of crude supply over demand. Increased production, above current expectation, for the Bering Sea, the Aleutian Island chain, the Gulf of Alaska, and the West Coast outer continental shelf could further aggravate a surplus situation. Estimates of undiscovered recoverable Alaskan oil range from 12 billion to over 76 billion barrels (15).

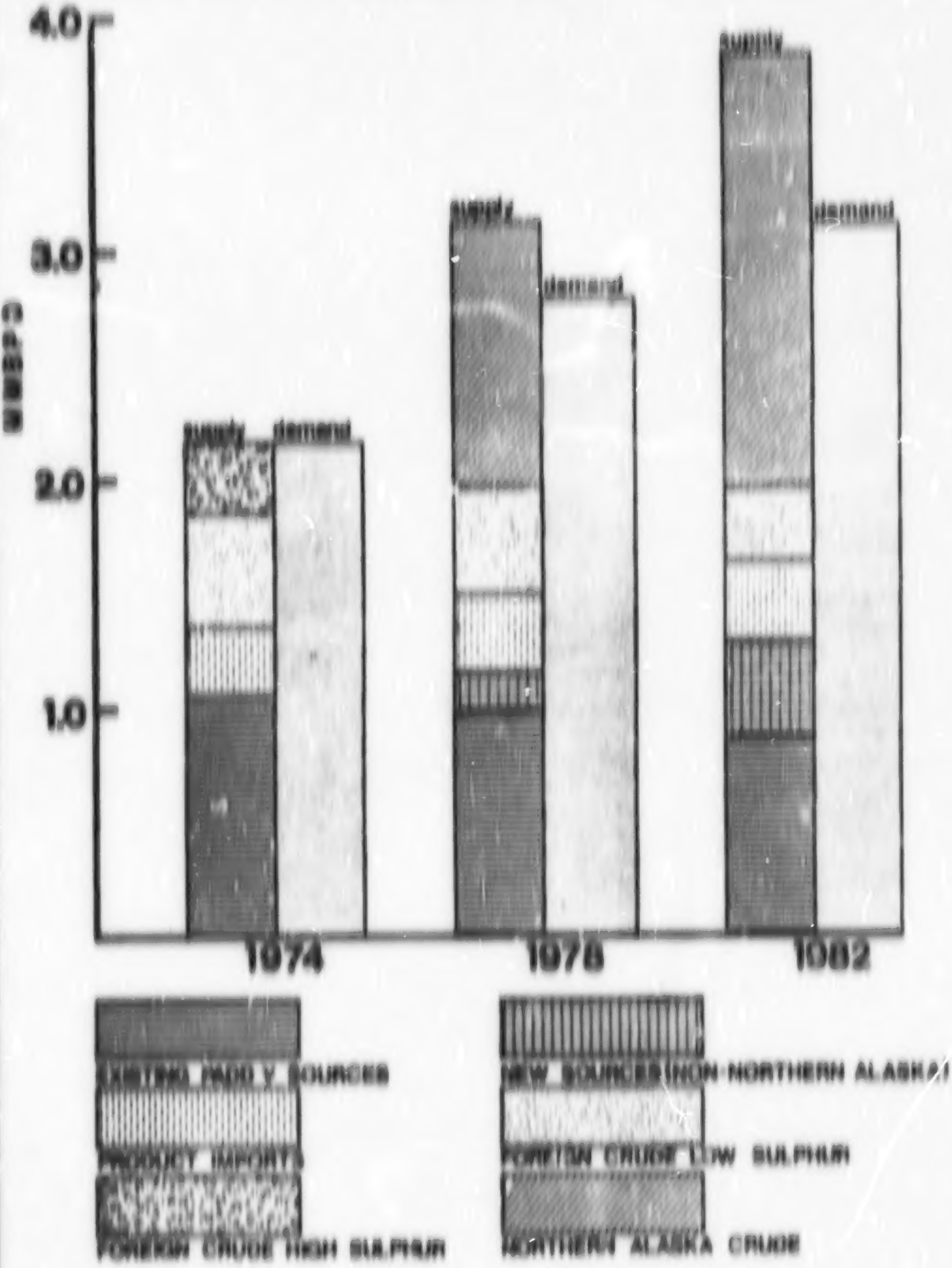

FIGURE 18: PADD V SUPPLY/DEMAND BALANCE FORECAST

SOURCE: Bureau of Land Management (20)

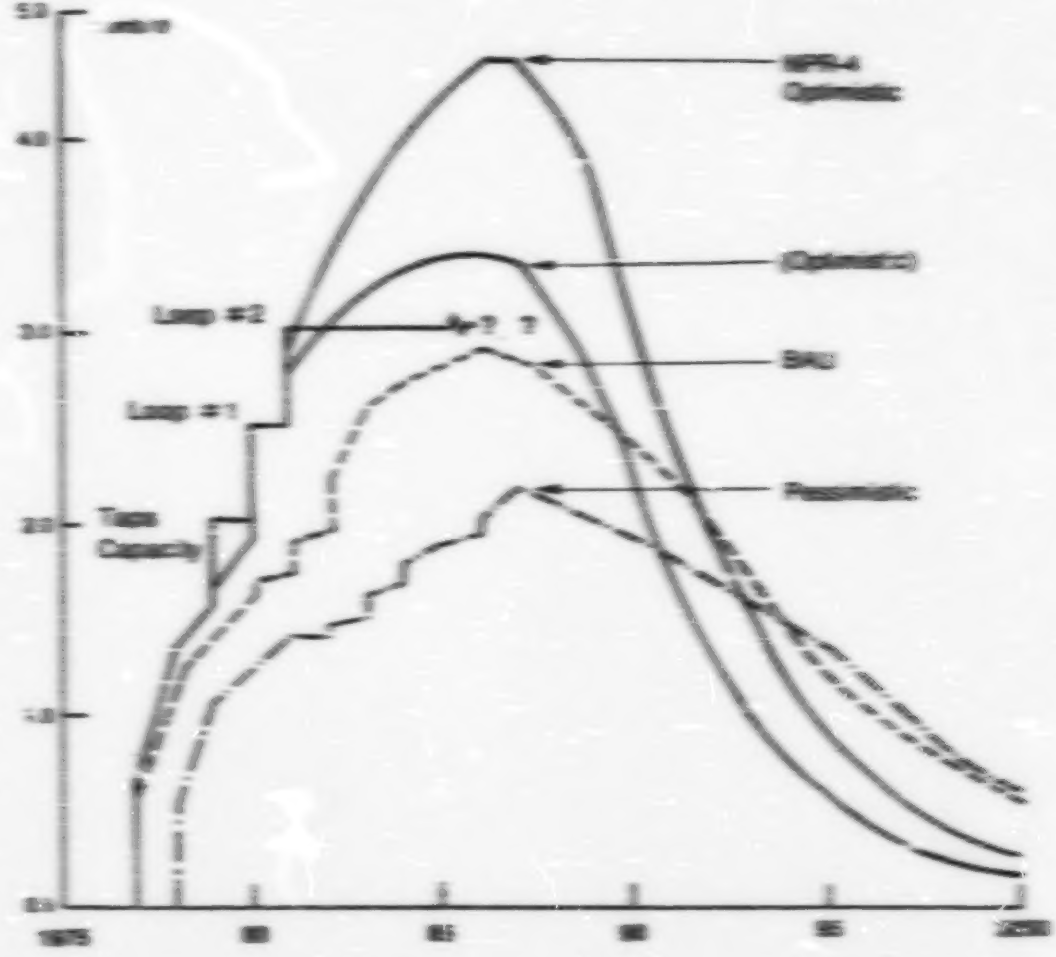

FIGURE 19: Outlooks for North Alaska crude production in 1975-2000
SOURCE: Federal Energy Administration (7)

The problem which emerges is how to handle the surplus. As many as 7,300 miles of pipeline solely within Alaska may be required (15). Thus, future Alaskan production may necessitate a new overland pipeline passing through Canada and which connects Alaskan crude reserves with eastern U.S. markets. Such a need was expressed in the Trans-Alaska Pipeline Act (12):

> A supplemental pipeline to connect the North Slope
> with a trans-Canada pipeline may be needed later and
> it should be studied now,...

Provisions were made within the Act for such a study to be conducted as well as for interactions with Canada on the terms and conditions under which pipelines (or other transportation systems) could be constructed across Canadian territory.

Thus, the potential for a large Alaskan and West Coast crude production to be realized within the next decade may require the development of a highly flexible and integrated crude oil distribution system. Such a system could serve all parts of the U.S. and could shunt oil from one port to another contingent upon supply or demand. The network also could serve to transport crude as needed during a national emergency and to circumvent faulty or destroyed trunk lines by circuitous routing in order to serve areas with low crude supplies.

An influx of unexpected crude production could induce a greater use of energy to the point where demand is equal to total crude supply. The judicious development of new crude reserves should be coupled with an effective fuel conservation policy. In this way, any newly found surplus of domestic crude could be substituted for foreign crude imports.

It may be in the national interest to develop a crude oil transportation system which will link various parts of the country. This system could provide long-term assistance in meeting future supply and demand needs. Current major transportation proposals such as the SOHIO Valdez to Midland, Texas project and the Northern Tier Valdez to Clearbrook, Minnesota should be able to fit into an overall transportation scheme. To promote flexibility, such a scheme also should include the ability of U.S. refineries to enter into large volume and long term exchange agreements with Canadian refineries. Such an intergovernmental linkage should be economically advantageous owing to lower transportation costs as compared to other options.

INFORMATION NEEDS

The following are a number of research or data compilation requirements identified during the course of this review. These studies are not necessarily recommended to be conducted by EPA, but indicate areas which warrant additional information, independent of agency sponsorship.

Broad Issues

Perspectives Study--

Sometime early in 1978, more than a million barrels of oil each day will flow southward through the Trans-Alaska pipeline from Alaska's North Slope and will be loaded into tankers' holds at the Port of Valdez. The oil's route after that is still uncertain (64). A study should be performed to explore how various transportation alternatives, if decided upon favorably, could preclude future flexibility to handle optimistic projections of future crude flows. The study should establish various scenarios concerning crude supplies through the year 2000 and project possible transportation solutions including an integrated crude distribution network. This study should address ramifications for various major crude oil transportation systems which compete for pipeline capacity such as the SOHIO crude vying with SEADOCK for space in the Williams and similar pipelines (Figure 10). The study should also explore the establishment and nature of a permanent interagency task force or commission to coordinate and oversee the development of petroleum transportation systems. The systems would include crude and product trunk lines and could be extended to encompass new, large scale gas transmission lines.

Implications of Alaska Gas Transportation Scheme for Crude Oil Transportation Alternatives--

The future of natural gas supplies to California is uncertain. Supply from both traditional sources and potential new sources cannot be reliably predicted. In the case of traditional sources, such as those east of the Rockies and Canada, an uncertainty exists as to the amount of gas which will be available. As for new sources such as liquified natural gas, synthetic natural gas, reserve additions, Alaskan gas, the timing of such projects is uncertain (36).

Three proposals are now before the Federal Power Commission for recommendation to the President. Congressional decision after review of the recommendation of the President could occur as early as November 1, 1977. The proposals in question are those of the Alaskan Arctic Gas Pipeline Company which favors bringing North Slope gas to the lower 48 states by a pipeline across Canada; the El Paso Alaska Company which proposes a pipeline parallel to the Trans-Alaska oil pipeline to a terminal near Valdez where the gas will be liquified (at a temperature of about minus 260 degrees Fahrenheit) and placed aboard special tankers for transport to California; and the Northwest Energy Company which proposes a pipeline from the North Slope along the Alcan Highway to points in northern British Columbia and Alberta where it may be connected to existing pipelines linked to the U.S. Any decision relevant to the amount of natural gas available to California, such as a decision to route gas from the Arctic Gas or Northwest systems exclusively to the Midwest and East, a position recently favored by the staff of the Federal Power Commission (65), or by converting the existing El Paso Texas-to-California gas pipeline to oil, could significantly affect economic and environmental conditions within the State (61). A reduction in natural gas supplies could lead to higher rates, limited use by residential consumers, interruption in gas service for commercial and industrial users (with possible job losses), and a curtailment of gas supplies to electric utilities. Consequently, the power plants would be forced to burn more fuel oil or to build new coal fired power plants in the California desert or in Utah, Arizona or Nebraska. Both alternatives would contribute to degradation of air quality. In addition, if substantial supplies of natural gas are diverted away from California, the state is likely to turn to the increased development of crude oil delivery and storage facilities, including deepwater ports with requisite dredging and other marine disruptions and possible air quality degradation. Such actions as these may have severe air quality implications for California as emissions of nitrogen oxides (precursors in the formation of smog) are increased 50 percent when fuel oil is burned instead of natural gas (66). In contrast, should the El Paso proposal be approved, California may not need to be so dependent upon crude oil for a residential or commercial energy source.

In the President's message upon signing the Alaska National Gas Transporation Act of 1976, he stated (67):

> This represents reducing U.S. oil import needs by about one-half million barrels per day. This will be a significant step towards energy independence. If the next Congress acts on my proposal for deregulation of new natural gas prices, long-term relief from natural gas shortages can be achieved.

Clearly, there are many areas where decision upon gas distributions systems interact with decisions based on oil distribution systems. A perspectives paper should be prepared which characterizes the interactions and subsequent implications of decisions based upon oil and gas alternatives. The report should suggest how communication and coordination may be established among the appropriate agencies. The report should also address the capability for fuel switching among various classes of interruptible customers and evaluate the adequacy of supply availability of alternative fuels, particularly in California, assuming normal, above average, and below average temperatures during a given heating season (68).

Special Issues

Puget Sound - A Special Case--

More than 500 ships travel through Puget Sound each day. Increasing numbers of these are tankers carrying crude to local refineries, often under foggy conditions (69). New proposals exist for an expansion of a deepwater marine terminal at Cherry Point within the Sound. The Northern Tier Pipeline Company proposes a marine terminal at Port Angeles on the Strait of Juan de Fuca. A unit train concept also involves a terminal in the Sound. Several variations of alternatives involve the building of an overland pipeline to connect Port Angeles with refineries north of Seattle. In 1978, FEA projects that almost 18 percent of the North Slope crude will be imported via the Sound (16).

Several alternatives which have been considered for importing oil into the State of Washington involved the construction of terminals and transfer systems on the Olympia Peninsula. These alternatives would provide for the transport of oil to existing refineries in northern Puget Sound (Ferndale and Anacortes areas). A report by the Oceanographic Commission of Washington (80) has indicated that a submarine pipeline crossing, particularly in the area of Admiralty Inlet, is technically feasible. Such a concept, except for relatively low volume service to refineries located in Tacoma, could alleviate the need for substantial tanker traffic to enter Puget Sound.

Studies of the economic and environmental aspects (81,82) of alternative marine terminal locations within the State of Washington have been conducted. These studies deal to some extent with the construction of pipelines to serve northern Puget Sound refiners, but lack in-depth analyses of comparative oil spill risks or other environmental impacts associated with a number of proposed sites for marine crossings.

The concept of utilizing submarine pipeline crossings to serve northern Puget Sound refineries should be explored in greater detail. Such a study should include the probability of oil spill risks in terms of frequency, oil spill trajectory, and environmental impacts. The study could compare environmental impacts of the present and projected transhipment of oil through the Sound with various land-submarine pipeline proposals, including an all submarine route.

New Approaches--

Two new approaches to deal with the projected surplus of North Slope crude oil on the West Coast have been proposed (70). These have not been fully explored and should be studied in detail. These include:

A. The expansion and modernization of existing West Coast refineries in order to increase their capacity to process sour (high sulfur) crude; and
B. Construction of one or more facilities (at Valdez, Kitimat, Port Angeles or elsewhere) to desulphurize and raise the gravity of North Slope crude oil, in order to use it in existing West Coast or Northern Tier refineries.

Secondary Impacts--

A study should be made of the environmental implications of induced development as a result of the importation of North Slope crude into California. The study should include a proposal by Dow Chemical to build a major new petrochemical plant in the Montezuma Hills, Solano County; a fuel refinery near Martinez proposed by Urich Oil Company; a fuel refinery at Carlsbad, San Diego County proposed by the Macario Independent Refinery Company; and a $1 billion petrochemical facility proposed by Atlantic Richfield Company which would adjoin the Dow plant in Solano County (61).

Studies Relating to Air Impacts

Field Studies and Data Collection--

The environmental assessment of the SOHIO project has required data to be collected from emission sources not normally sampled. These sources include tanker stacks, fugitive emissions from cargo holds, and floating roof storage tanks. Barely any work had been performed which involved measurement of emissions from tankers during the unloading process until the SOHIO project evaluation was well underway. Operational data need to be collected for baseline reference analyses on these sources. For example, should an inerting system fail to operate, venting to the atmosphere could take place. The rates of failure and the occurrence of resultant venting should be documented.

A field study also should be conducted on the sources of NO_x during combustion prior to stack emissions from tankers. There is some question as to whether the NO_x emissions are derived largely from nitrogen in the fuel or from the combustion process with atmospheric N_2. Should fuel nitrogen be a large contributor to NO_x emissions, removal procedures involving fuel treatment would be necessary to reduce emissions.

Air Quality Models--

The results of the models utilized by various consultants when evaluating the impact of the SOHIO-Port of Long Beach marine terminal differed considerably, especially for reactive hydrocarbons and for oxides of nitrogen. Special considerations may be required to model tanker emissions which are not currently incorporated into generalized models.

Of critical importance in the analysis of emissions impact on air quality is the calculation of probabilities, or likelihoods, of situations occurring that will result in maximum emissions at meteorologically poor times. These probabilities of joint events of various types (including meteorological conditions) occurring for extended periods of time were not included in the studies to date. Futher, the relevant probabilities for "worst case" situations should be related to air quality standards such as:

$\frac{1}{365}$ = probability of violating California daily standard

$\frac{2}{365}$ = probability of violating National daily standard

$\frac{1}{365x24}$ = probability of violating California hourly standard

$\frac{2}{365x24}$ = probability of violating National hourly standard

The models assumed worst imagined combinations of events which led to extreme air quality degradation. But, in the final analysis it was understood that the chances of the worst case ever happening within a reasonable length of time were remote, so that the worst case was discounted as being unlikely. What is actually going to occur within the lifetime, and as a result, of the project is important, not the rare combination of events which will cause the most severe pollution load.

Generally there is a need for the development of an analytical model which would be well documented with respect to assumptions, constants, background data, etc. The model would first simulate in-port queueing to establish emissions rates. Steady-state conditions would be assumed with the exception of delays due to seasonal weather conditions. Inputs to the queueing model would include operational modes and times, tanker types, emission factors, etc. In conjunction with the queueing model, meteorological conditions would be categorized (e.g. wind speeds and direction, stability, etc.) and their probabilities of occurrence calculated by season. An air quality analysis for each meteorological condition and season combination would then be performed in a "backward" mode to determine the emissions necessary to cause air quality standard violations. The resultant emissions levels would then be compared to the queueing model results to determine the frequency of violations, if any, and their associated probability of occurrence. Such a model should be published, widely circulated, and treated as non-proprietary information. A detailed user's manual should accompany the model.

Guidelines for Assessing Terminal Air Quality Impacts--

A set of guidelines should be developed which provide conformity in the establishment of assumptions which set the stage or conditions upon which emission factors are determined for the air quality analyses of proposed marine terminals. The guidelines would recommend approaches to the development of scenarios involving numbers of tankers in port simultaneously, the duration of such a joint condition, the length of travel into port associated with air quality implications, etc. The guidelines would provide common ground for the development of worst case, business-as-usual, and best case scenarios and consequent emission factors for the evaluation of new port facilities.

Assessment of Tanker Emissions and Controls--

This report has summarized various studies which have evaluated potential impacts upon air quality associated with emissions from tankers expected to transport North Slope crude oil. Such impacts may be existent to some degree in ports currently engaged in the loading and unloading of crude oil or the products of its refinement. A broad, nationwide technology assessment should be undertaken to define the current and projected magnitude of the problem, the state of current control technology practice, the potential individual and system integrated control measures, the policy and institutional mechanisms for implementing emission abatement measures, and national control strategy scenarios with concomitant economic, environmental, and social effects.

The study should include: current and projected tanker traffic patterns and cargos associated with U.S. ports; current and projected emission factors and their potential impacts within various air quality control regions; existing and potential use of vapor recovery systems, on board gas scrubbers and inerting systems, terminal waste gas treatment, complete segregated ballast capability, combustion modification for emission control, on board and dockside closed system monitoring of oil or product volume and rate of flow, use of low sulfur fuel, bilge and cargo hold cleaning, and curtailment of emissions via operational controls; and existing or potential water, land, or noise impacts associated with the abatement of air emissions from tankers or conversely, impacts upon air quality associated with the control of water, land, and noise pollution.

Studies Related to Water Impacts

Vessel Traffic Control System--

A study should be undertaken to determine the feasibility of developing, implementing, and operating a multi-regional vessel traffic control system. The study should consider an area extending from Valdez, Alaska to the Panama Canal. Such a system could utilize standard, durable, and certified equipment including preferred corridors of tanker traffic movement, navigational buoys, primary and backup radar, Loran C, transponders which automatically report position and identification, ship-to-ship and ship-to-shore radio, primary and backup gyrocompasses, Fathometers, emergency generators, fire fighting and damage control equipment and procedures, operating rules for pilots and tugs, backup boilers, rudder systems, propellers, and certification of officers and crew (70,71). It is envisioned that such a system could operate similar to an air traffic control system and would be under jurisdiction of the U.S. Coast Guard. Legislation may need to be enacted to provide legal authority over U.S. and foreign vessels operating in a pre-defined zone (perhaps 200 miles offshore) as proposed in current legislation (83,84).

Double Hulls--

Proponents of double hull tankers maintain that the sides and bottom of a tanker's cargo compartment should be separated from the ship's outer hull to prevent accidental oil spills should the hull be pierced. This outside compartment could be used to store ballast water to prevent its contact with the oily cargo. Adversaries of the concept maintain that such double bottoms could cause explosions by providing an enclosed space into which oil fumes could leak (71). Some maintain that a double hulled tanker which has pierced its hull in a grounding is difficult to refloat. Others feel that double sides in addition to double bottoms are not warranted for tankers. A study of the state-of-knowlege concerning these tankers should be undertaken to evaluate the pros and cons of the concept.

Setting a Precedent

The SOHIO project is the first major energy project to come under the policy that trade-offs for new stationary source air emissions would be a required mitigation measure as set forth in newly proposed stationary source review rules. The location of the project in a non-attainment area has forced stringent mitigating measures to be employed in order to be in compliance with accepted air quality regulations. Some of these measures may include the use of low-sulfur fuel, segregated ballast, inerting systems, avoidance of purging operations in port or near shore, use of exhaust scrubbers, vapor recovery system on storage and cargo tanks, restricted ballasting in port (for ships with partially segregated ballast), automatic closing valves on the pipeline, foam-covering systems to blanket oil spills, and trade off of project derived hydrocarbon emissions by the curtailment of local hydrocarbon emissions by an equal or greater amount.

The imposition of these measures as permit conditions by regulatory agencies could be detrimental to an incentive on the part of proponents of similar energy projects. Such sponsors may not possess the financial backing in the form of capital to invest in the use or development of relatively expensive pollution abatement devices. Thus, in similar situations where a project which provides an energy supply seeks to attain environmental compatibility, the SOHIO project could represent a model. It is suggested that this situation be explored for its precedent setting potential and resultant ramifications.

REFERENCES

1. Office of Communication. 1976. Success at Oil Creek August 27, 1859. Department of the Interior, Washington, D.C. 16 pp.

2. Petroleum Extension Service. 1966. Introduction to the Oil Pipeline Industry. The University of Texas, Austin, Texas. 84 pp.

3. American Petroleum Institute. 1975. Crude Oil Pipeline Map of the United States and Southern Canada. Washington, D.C.

4. American Petroleum Institute. 1975. Basic Petroleum Data Book. Petroleum Industry Statistics. Washington, D.C.

5. National Petroleum Council. 1971. Environmental Conservation. The Oil and Gas Industries/Volume One. Washington, D.C. 106 pp.

6. Dyne, Norma W. 1972. North Alaska Oil and Related Issues. Congressional Research Service, Washington, D.C. 105 pp.

7. Federal Energy Administration. 1976. National Energy Outlook. Washington, D.C.

8. Business Week. 1969. Alaska Strikes It Rich. February 1, 1969, pp. 49-53.

9. Concluding remarks in a statement by Secretary of the Interior, Rogers C. B. Morton Concerning the Application for a Trans-Alaska Pipeline Right-of-Way. May 11, 1972, Department of the Interior Press Release.

10. Tussing, Arlon. 1974. The Trans-Alaska Pipeline and West Coast Petroleum Supply, 1977-1982. A Staff Analysis Prepared at the Request of the U.S. Senate Committee on Interior and Insular Affairs Pursuant to Senate Resolution 45 (National Fuels and Energy Policy Study).

11. Excerpt from a report to the U.S. Senate from the Committee on Interior and Insular Affairs which Accompanied the Federal Lands Right of Way Act of 1973 (S. 1081).

12. Trans-Alaska Pipeline Act of 1973 (PL 93-153). Enacted by Congress November 13, 1973, and signed by President Nixon November 15; Amended by the Energy Policy and Conservation Act, PL 94-163, December 22, 1975.

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REFERENCES

(Continued)

13. Engineering News - Record. 1976. $1-Billion Alaska Oil Terminal Braces for Snow and Quakes. June 3, 1976, pages 18-19.

14. Wilson, Howard M. 1976. Beefed-up Tanker Fleets Readied for North Slope Oil. The Oil and Gas Journal, June 14, 1976, pages 23-26.

15. Hodgson, Bryan. 1976. The Pipeline: Alaska's Troubled Colossus. National Geographic 150(5): 684-717.

16. Federal Energy Administration. 1976. An Analysis of the Alternatives Available for the Transportation and Disposition of Alaskan North Slope Crude. Final Draft Report Dated November 30, 1976. Washington, D.C. 891 pp.

17. Hill, John A. 1976. Statement Before the Senate Interior and Senate Commerce Committees. September 21, 1976.

18. Federal Energy Administration. 1976. Crude Oil Supply Alternatives for the Northern Tier States. Washington,D.C. 51 pp.

19. Canadian News. 1976. Interprovincial and Trans-Mountain Pipe Line. Pipeline and Gas Journal, August, 1976. p. 16.

20. Bureau of Land Management. 1976. Draft Environmental Impact Statement. Crude Oil Transportation System: Valdez, Alaska to Midland, Texas (As Proposed by SOHIO Transportation Company. Department of the Interior, Washington, D.C.

21. Oilweek. 1976. Kitimat Studied for Crude Oil Pipeline. May 31, 1976, pp. 82-83

22. The Oil and Gas Journal. 1976. Canadian Oil Line Plans Yo-Yo Operation. December 13, 1976. p. 41.

23. National Fisherman. 1976. Washington Determined to Control Tanker Movements in Puget Sound. December, 1976.

24. Northern Tier Pipeline Company. 1976. Supplement Number 2 to the Northern Tier Pipeline Company's Application for Site Certification. Submitted to the Washington State Energy Facility Site Evaluation Council on November 19, 1976.

25. Northern Tier Pipeline Company. 1976. The Northern Tier Pipeline Concept. Billings, Montana.

REFERENCES

(Continued)

26. Beasley, James R. 1977. Review Comments on The MITRE Corporation's Draft Report "Seeking Environmental Compatibility: A review of Environmental Issues Related to the Transportation of Alaskan North Slope Crude Oil." Butler Associates, Inc., Tulsa, Oklahoma.

27. The Oil and Gas Journal. 1976. Northern Tier Wants Permits, Then Oil Buyers. June 14, 1976. p.27.

28. The Oil and Gas Journal. 1976. The Puget Sound. March 29, 1976. p. 74.

29. Richards, Bill. 1977. Energy vs. Environment: Clash on West Coast. The Washington Post. January 10, 1977.

30. Federal Energy Administration. 1976. North Slope Crude: Where to? How? Washington, D.C.

31. Concern expressed by Assemblyman Charles Warren of the California Legislative in a Speech Entitled "The State Government's Response to Alaskan Oil and Gas" Presented at the "Oil and Gas from Alaska: Choices for California" Conference held at the University of South California, Los Angeles and Sponsored by the Center for California Public Affairs, Claremont, California. November 20-21, 1976.

32. A Goal of Project Independence launched by President Nixon on November 7, 1973. For a Discussion of the Program Policy see: Hans Umlauf. 1974. Project Independence? The Hard Questions Ahead. In The World Almanac and Book of Facts 1975. Newspaper Enterprise Association, Inc., New York. 976 pp.

33. Hornblower, Margot. 1976. Zarb of FEA Opposes Exporting Alaskan Oil Surplus. The Washington Post. December 1, 1976.

34. Gregg, Bill. 1976. Oil Swap With Japan Gets Strong Backing. The Oil Daily. December 9, 1976.

35. The Oil and Gas Journal. 1976. FEA Sees N. Slope Oil Exports Needed. September 27, 1976.

36. Port of Long Beach and the California Public Utilities Commission 1976 Draft Environmental Impact Report: SOHIO West Coast to Mid-Continent Pipeline Project. September 1976.

37. Platt's Oilgram News Service. 1976. California Board Reported Eyeing Offshore Crude Port. November 16, 1976.

REFERENCES

(Continued)

38. Naval Facilities Engineering Command. 1976. Environmental Impact Assessments of Alternate Routes for Crude Oil Transport Naval Petroleum Reserves in California-Elk Hills. Office of Naval Petroleum and Oil Shale Reserves, San Bruno, California.

39. Platt's Oilgram News Service, 1976. Navy Issues Bid Invitation. November 16, 1976.

40. Pipeline and Gas Journal. 1976. Navy Plans Pipeline from Elk Hills Field. November, 1976.

41. Jackson, Henry M. 1976. Opening Statement Before the Joint Interior and Commerce Hearing on the Effect of the Trans-Alaska Pipeline on the West Coast Crude Oil Supply. September 21, 1976.

42. Wilson, Howard M. 1974. Prudhoe Oil Will Bring Profound Change to West Coast Crude-Flow Patterns. The Oil and Gas Journal, March 18, 1974, pages 96-100.

43. Nehring, Richard. 1976. Mitigating and Offsetting Emissions from West-East Oil Movement. Draft Working Note Dated December 21, 1976. Rand Corporation, Santa Monica, California, 34 pp.

44. Platt's Oilgram News Service. 1976. Senators Hear Contrasting Views of SOHIO Terminal's Eco-Effects. December 8, 1976.

45. Stevens, Ted. 1976. Statement Before the Senate Commerce and Interior Committees Regarding Distribution of North Slope Crude Oil. September 21, 1976.

46. White, Robert A. 1976. FEA to Meet Early Storage Goal--Noel. Highlights, October 26, 1976. Office of Communications and Public Affairs, Federal Energy Administration, Washington,D.C.

47. Pacific Environmental Services, Inc. 1976. Final Report-Air Quality Analysis of the Unloading of Alaskan Crude Oil at California Ports. Prepared for the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.

48. SOHIO Transportation Company. 1976. Impact of the SOHIO Project on Air Emissions in the Long Beach Port Area. Report Dated August 20, 1976. Midland Building, Cleveland, Ohio.

49. Teknekron, Inc. 1976. Air Quality Impact Evaluation of Candidates Sites for an Alaskan Oil Transfer Terminal in the Pacific Northwest. Draft Report Dated July 31, 1976, Submitted to Region X, U.S. Environmental Protection Agency, Seattle, Washington.

REFERENCES

(Continued)

50. Chicago Bridge & Iron Company. 1976. SOHIO/CBI Floating Roof Emission Test Program. Final Report Dated November 18, 1976. Oak Brook, Illinois.

51. Mackenzie, John F. and Charles T. Rao. 1976. Gaseous Hydrocarbon Emissions During the Loading of Marine Vessels. Paper Presented at the 69th Annual Meeting of the Air Pollution Control Association, Portland, Oregon. June 27-July 1, 1976.

52. U. S. Coast Guard. 1976. Final Environmental Impact Statement-Regulations for Tank Vessels Engaged in the Carriage of Oil in Domestic Trade. Department of Transportation, Washington, D.C.

53. Office of Air and Waste Management. 1975. Compilation of Air Pollutant Emission Factors. (2nd Edition) AP-42. U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

54. Esso Research and Engineering Company. 1974. Survey of Ship Discharges. Final Report on Task I, Sub-Task 1 (Contract No. C-1-35049). Prepared for the Office of Research and Development, Maritime Administration, U.S. Department of Commerce, Washington, D. C.

55. American Petroleum Institute. 1962. API Bulletin on Evaporation Loss from Floating-Roof Tanks. (API Bulletin 2517). Washington, D.C.

56. Time. 1977. Oil is Pouring on Troubled Waters. January 10, 1977.

57. Kifner, John. 1977. Tanker Loss Record Set Last Year. The Washington Star. January 10, 1977.

58. United Press International. 1977. Tankers' Troubles Spread Globally; 1 Missing 7 Days. The Washington Star. circa. January 10, 1977.

59. Environmental Research & Technology. 1976. SOHIO Crude Oil Transportation System Tanker Traffic Study. Prepared for the Bureau of Land Management, Department of the Interior. (Contract No. YA152-CT6-101).

60. Cicchetti, Charles J. 1972. Alaskan Oil: Alternative Routes and Markets. Resources for the Future, Inc., Washinrton, D.C. 142 pp.

61. Center for California Public Affairs. 1976. Background paper prepared for participants in the conference entitled Oil and Gas from Alaska: Choices for California held at the Davidson Conference Center, University of Southern California, November 20-21, 1976.

62. Harris, Carolyn. 1973. In Productive Harmony: Environmental Impact Statements Broaden the Nation's Perspectives. Office of Public Affairs, U.S. Environmental Protection Agency, Washington, D.C.

REFERENCES

(Continued)

63. Council on Environmental Quality. 1976. Environmental Impact Statements: An Analysis of Six Years' Experience by Seventy Federal Agencies. Washington, D.C.

64. Los Angeles Times. 1976. Letting the Oil In. September 21, 1976.

65. Anderson, Allan W. Jr., and Brian J. Heisler. 1976. Position Brief of the Commission Staff. Federal Power Commission, Washington, D.C. December 7, 1976 (Docket No. CP 75-96, *et al*).

66. Federal Power Commission Staff. 1975. Comments on behalf of the Southern California Air Pollution Control District Regarding the Staff's Draft Environmental Impact Statement. Contained within the Final Environmental Impact Statement, El Paso Natural Gas Company (Docket No. RP 72-6) 502 pp.

67. Ford, Gerald R. 1976. Statement upon signing S.3521 (The Alaska Natural Gas Transportation Act of 1976) into Law. Presidential Documents 12(66):1563.

68. Interagency Natural Gas Task Force. 1976. Recommended Actions to Alleviate the Natural Gas Shortage in California. Energy Resources Conservation and Development Commission, Sacramento, California.

69. Graves, William. 1976. Sea of the Pacific Northwest: Puget Sound. National Geographic 151(1):71-97.

70. The Washington Star. 1977. Senate is Readying Probe of those Oil Tanker Spills. January 9, 1977.

71. Mayer, Allan J. 1977. How to Make Tankers Safer. Newsweek: January 17, 1977.

72. U.S. Environmental Protection Agency. 1976. Review of New Sources and Modifications. Federal Register 41(246): 55558-55561, December 21, 1976.

73. Bureau of Land Management. 1977. Review comments on The MITRE Corporation's Draft Report, "Seeking Environmental Compatibility: A review of environmental issues related to the transportation of Alaskan North Slope Crude Oil." Department of the Interior, Los Alamitos, California.

74. U.S. Environmental Protection Agency. 1977. Review comments on the MITRE Corporation's Draft Report, "Seeking Environmental Compatibility: A review of environmental issues related to the transportation of Alaskan North Slope Crude Oil". Region X, Seattle, Washington.

REFERENCES
(Concluded)

75. Nehring, Richard. 1977. Mitigating and Offsetting Emissions from West-East Oil Movement. WN-9719-CEQ. Feuruary, 1977. Rand Corporation, Santa Monica, California, 47 pp.

76. Air Resources Board, State of California. 1977. Preliminary Analysis of the Proposed SOHIO Marine Terminal at the Port of Long Beach. SS-76-035. December 16, 1977. Sacramento, California.

77. SOHIO Transportation Company. 1977. Supporting Information for the SOHIO Permit Application Prepared for the Southern California Air Quality Management District. February, 1977. Cleveland, Ohio.

78. Port of Long Beach. 1977. Overview SOHIO-West Coast to Mid-Continent Pipeline Project. January, 1977. Environmental Affairs Division, Long Beach, California.

79. Office of Planning and Research, State of California,. 1976. Is San Luis Obispo Bay a Realistic Alternative Meriting Further Study if the SOHIO Proposal for a Deepwater Terminal to Receive Alaskan Oil at Long Beach Fails to Meet Prescribed Environmental Standards? October 28, 1976. Sacramento, California.

80. Oceanographic Commission of Washington. 1975. Submarine Pipeline Crossings of Admiralty Inlet, Puget Sound: A study of technical feasibility. Seattle, Washington.

81. State of Washington. 1976. Assessment of Alternative Crude Oil Marine Terminal Locations in Washington State. Economic Policy Analysis Division, Department of Commerce and Economic Development, Seattle, Washington.

82. State of Washington. 1976. A Report on: A Comparative Assessment of Three Proposed Operational Port-Terminal Facilities. Department of Ecology, Seattle, Washington.

83. Senate Bill 182. The "Federal Tanker Safety and Marine Anti-Pollution Act of 1977." 95th Congress, 1st. Session.

84. Senate Bill 682. The "Tanker Safety Act of 1977". 95th Congress, 1st. Session.